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## **OSMOTIC DRYING AND NUTRIENT INFUSION OF FRUITS AND VEGETABLES**

by  
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**\*CherryCentral, Inc.  
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**U. S. Army Soldier and Biological Chemical Command  
Soldier Systems Center  
Natick, Massachusetts 01760-5018**

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This paper describes studies done with the osmotic drying and nutrient infusion of fruits and vegetables. Sensory testing was performed on the products. They were packaged, placed in storage and the percent moisture, water activity and reflectance color determined for periods up to two years of storage at 40, 70 and 100 degrees Fahrenheit. Initially, six commercial fruit products were chosen for long-term storage. Two representative products, mango-flavored apple cubes and cherries, were then prepared with infused vitamins and minerals. The commercial product, cranberries, was also studied intensively. Vegetables, potatoes, carrots and celery were also prepared with infused vitamins and minerals. It was concluded that highly acceptable, osmotically-dried fruits with infused nutrients could be prepared. However, the commercial package was unacceptable. A barrier package was necessary for long-term stability. The vegetables were less successful. These products were successfully prepared, but received less than acceptable sensory ratings.

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## **PREFACE**

This report describes a series of tests conducted over a three year period with many different osmotically dried fruit and vegetable products.

The first set of tests was conducted on six commercial fruit items: whole pitted cherries, whole blueberries, whole strawberries, mango flavored apple cubes, passion-fruit flavored apple cubes and cinnamon flavored apple slices. These tests were done over a two year storage study. The data for the first year of storage was reported in a Natick Technical Report (1997) TR 97/011.

The second set of tests was conducted with four different nutrient enhanced fruit products that had added nutrients: mango flavored apple cubes with folic acid, mango flavored apple cubes with Zn and Mg, whole pitted cherries with folic acid and whole pitted cherries with Zn and Mg. These tests were again done over a two year storage study. The data for the first year of storage was reported in a Natick Technical Report (1998) TR 98/023.

The third set of tests was conducted with three vegetables with added nutrients: cubed carrots with folic acid and vitamin B<sub>12</sub>, cubed carrots with Zn, Mg and Ca, cubed potatoes with folic acid and vitamin B<sub>12</sub>, cubed potatoes with Zn, Mg and Ca, sliced celery with folic acid and vitamin B<sub>12</sub>, sliced celery with Zn, Mg and Ca. The data on the first two tests showed that a six month storage study would be sufficient to show changes.

The final set of tests was conducted with whole cranberries with added folic acid and vitamin B<sub>12</sub> and whole cranberries with added Zn, Mg and Ca. Another six month storage study was conducted with these products.

The results of all these studies are reported here.

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Citation of trade names in this report does not constitute an official endorsement or approval of the use of such items.

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# OSMOTIC DRYING AND NUTRIENT INFUSION OF FRUITS AND VEGETABLES

## INTRODUCTION

The military services have a need for low and intermediate moisture foods of enhanced nutrition and high sensory acceptability with a reduced cost of processing. Such foods will provide a high density of nutrients, calories, etc. There would also be a potential for extended high quality shelf-life. Osmotic dehydration is such a low cost operation that has many advantages. The infusion of additional nutrients such as vitamins and minerals, into the food during the osmotic drying will further enhance the low moisture rations. The products would be processed at lowered temperatures, thus enhancing the sensory acceptability. Because of the lowered processing temperatures there would be less nutrient loss.

Cohen and Yang did a series of bench-top studies in which they investigated the parameters that needed to be controlled during the osmotic drying processing. This was reported in a Natick Technical Report (1995) TR95/034. Lazarides 1994 studied the osmotic preconcentration of fruits and vegetables. He concluded that this is an effective way to reduce overall energy requirements in dehydration. The subsequent mild heat treatments results in products with superior organoleptic properties. Lenart also studied initial osmotic predrying of fruits. He concluded that osmotic drying prior to convection drying results in a decreased rate and degree of rehydration as well as a decreased water vapor adsorption rate and equilibrium water content. Fito, et al. studied the vacuum osmotic dehydration of fruits and vegetables. Several advantages were found, in comparison to regular osmotic drying, including a faster kinetic for water loss, and better sensorial properties. Also, there was greater stability in relation to browning and oxidation.

## METHODS OF ANALYSIS

The methods of analysis, both chemical and physical, as well as sensory testing, were common to all the storage studies.

### Physical Analyses

#### Percent Moisture - Radiant Heating Method

This analysis used a Computrac Max-50 <sup>TM</sup> radiant heating moisture analyzer. The temperature was set at 150 °C (302 °F). The value reported is a single measurement.

#### Percent Moisture - Vacuum Oven Method

This analysis was the standard AOAC method (1995). The reported values are the average of duplicate measurements.

#### Water Activity ( $A_w$ )

This analysis used an Aqua Lab Model CX-2 <sup>TM</sup> meter. The reported values are the average of duplicate measurements.

#### Reflectance - Hunter L, a, b

A Pacific Systems Spectrogard Reflectometer, Model 96 <sup>TM</sup> was used for these measurements. The measurements were made through a 2.2 cm (0.875 in) diameter viewing window. The reported values are the average of quadruplicate measurements. A greater L value indicates a lighter color; a greater negative a value indicates more red, less green; a greater b value indicates more yellow, less blue.

## **Chemical Analyses**

### **Minerals, Mg, Zn, Ca**

These analyses were standard AOAC methods. All the data is transformed to 100% dry weight basis using the radiant heating moisture method.

### **Folic Acid**

An in-house high pressure liquid chromatography (HPLC) method was devised. This consisted of a reverse phase phenyl column using UV detection at 280 nm with an 11:89 (acetonitrile/0.33 M phosphate buffer adjusted to pH2.3) mobile phase. Folic acid eluted in approximately 10 minutes at a flow rate of 1 ml/min. However confounding species were found during the analyses so only the data for the vegetables could be used. All the data is transformed to 100% dry weight basis using the radiant heating moisture method.

### **Vitamin B12**

Although an HPLC method was developed it did not give useful data because the amount added to the cranberries was too low to be detected without a preconcentration step. The amount added was based on the minimum daily requirement which is given in the Appendix.

### **Sensory Testing**

Except for the vegetables which were rehydrated, no special preparation was done with the fruits prior to sensory testing, except that they were served at room temperature.

### **Consumer Panel**

This testing was done at Natick by the regular, untrained consumer panel that consisted of 36 or 37 participants. The panelists evaluated for overall acceptability as well as flavor, color and texture as well. They used a 9-point hedonic scale with a range of 1-dislike extremely to 9-like extremely with 5-neither like nor dislike. The panelists were also asked to comment on the products.

### **Technical Panel**

This testing was also done at Natick by the regular, trained technical panel that consisted of fifteen participants. The panelists evaluated for overall acceptability as well as appearance, odor, flavor and texture using the same scale as the consumer panel.

### **Field Tests**

These tests were done by soldiers during a course of evaluation of new MRE items. The products were evaluated for overall acceptability only.

## **COMMERCIAL FRUIT PRODUCTS**

The purpose of this study was to determine if commercial osmotically dried fruit products were acceptable for use by the military from a standpoint of sensory acceptability and stability on storage. The products were manufactured by the Cherry Central Co. They were prepared from thawed IQF fruit by initially drying in a concentrated (42 Brix) sucrose/ fructose solution in a temperature controlled kettle at 55 °F (13 °C) for 234 hours. The fruit was then drained and placed in a convection dryer at 175 °F (79 °C) for four hours. Preliminary data was reported by Cohen, Yang and Atwood in a Natick Technical Report (1997).

## Products

The products studied are shown in Table 1.

**TABLE 1 - DESCRIPTION OF COMMERCIAL FRUIT PRODUCTS**

<u>Fruit</u>	<u>Description</u>	<u>Ingredients</u>
A. Cherries	1.2 - 1.8 cm (0.50 - 0.75 in)	whole pitted tart cherries, sucrose, sunflower oil
B. Blueberries	0.6 - 0.9 cm (0.25 - 0.38 in)	whole blueberries, fructose, corn syrup, malic acid, sunflower oil
C. Strawberries	1.8 - 3.0 cm (0.75 - 1.25 in)	whole strawberries, fructose, corn syrup, blueberry juice
D. Apple Cubes	0.6 cm (0.25 in)	apples, high fructose corn syrup, ascorbic acid, citric acid, NaCl, sunflower oil, natural mango flavor
E. Apple Cubes	0.6 cm (0.25 in)	apples, sucrose, cherry juice concentrate, ascorbic acid, citric acid, NaCl, sunflower oil, natural passion fruit flavor, sunflower oil
F. Apple Slices	1.8 - 5.0 cm (0.75 - 2.0 in) x 0.3 cm (0.13 in) thickness	apples, cherry juice sweetened with sucrose, natural cinnamon flavor

## Packaging

The products were received in the CherryCentral commercial packaging material. This was clear laminated film supplied by the American National Can Co. to the following specifications:

MVTR (moisture vapor transmission rate) - 0.3 g/100 sq in/24 hours at 100 °F and 90% relative humidity

Oxygen transmission -  $-0.6 \text{ cm}^3/100 \text{ sq in/24 hrs}$  and 0% relative humidity

Each package contained approximately 110 g (3.9 oz). Because of the size of the apple slices, those packages were larger than the others.

In all the studies there was ambient head space gas in the package

## Storage Conditions

40, 70, 100 °F (4, 21, 38 °C) and withdrawals at one, three, six, nine, twelve, eighteen and twenty-four months.

120 °F (49 °C) for one month. These samples were used for accelerated sensory testing. (It is generally accepted that this is equivalent to 3 years at 70 °F.)

## Results

### Sensory Testing

#### Consumer Panel

Table 2 are the panel scores for both the initial testing without storage and after one month storage at 120 °F.

**TABLE 2 - CONSUMER PANEL SCORES OF COMMERCIAL FRUIT PRODUCTS**

	No Storage Time						1 Month Storage at 120 °F					
	Product						Product					
	A	B	C	D	E	F	A	B	C	D	E	F
Number of Scores												
<u>Score</u>												
<u>a. Overall Acceptability</u>												
9	7	4	1	1	2	3	0	0	1	0	0	1
8	9	3	2	7	5	3	5	3	3	8	1	4
7	8	11	6	3	8	10	8	9	4	12	2	7
6	4	7	5	9	3	8	9	7	2	5	7	6
5	4	3	2	8	4	2	7	9	7	7	10	7
4	3	5	8	4	7	6	6	2	9	3	6	6
3	0	2	3	1	5	0	3	4	7	1	9	3
2	1	1	5	2	2	4	1	2	4	1	1	2
1	0	0	3	1	0	0	0	0	1	0	1	1
N	36	36	36	36	36	36	36	36	36	37	37	37
Mean	6.9	6.2	4.6	5.7	5.5	5.9	5.6	5.5	4.4	6.2	4.5	5.4
SD	1.8	1.8	2.2	1.9	2.1	2.0	1.7	1.7	1.8	1.6	1.5	1.9
<u>b. Flavor</u>												
9	7	6	3	2	1	4	4	1	1	0	1	0
8	9	3	3	5	7	5	3	3	1	1	0	5
7	9	12	5	3	6	9	15	12	7	6	7	4
6	7	7	5	10	5	8	4	9	11	6	9	9
5	4	1	2	9	2	4	6	6	4	3	5	5
4	1	5	5	4	10	3	2	2	6	10	8	9
3	2	0	7	1	4	1	0	2	3	6	6	5
2	1	1	5	2	2	4	2	1	3	5	1	0
1	0	0	3	0	0	0	0	0	0	0	0	0
N	36	36	36	36	36	36	36	36	36	37	37	37
Mean	6.8	6.5	4.9	5.8	5.6	6.3	6.4	6.0	5.3	4.6	5.1	5.4
SD	1.9	1.9	2.4	1.7	1.9	1.9	1.7	1.5	1.7	1.8	1.6	1.6
<u>c. Color</u>												
9	5	4	0	4	3	4	4	1	1	0	0	2
8	10	5	4	4	3	2	5	4	3	2	1	5
7	4	6	2	10	3	7	10	6	2	8	7	7
6	11	10	2	3	9	12	6	10	8	8	11	10
5	3	6	5	13	8	5	6	5	5	10	4	5
4	2	3	11	0	6	4	0	8	8	2	9	5
3	1	1	5	2	2	0	3	1	4	4	4	3
2	0	1	5	0	2	2	1	1	5	2	1	0
1	0	0	2	0	0	0	1	0	0	1	0	0
N	36	36	36	36	36	36	36	36	36	37	37	37
Mean	6.8	6.3	4.3	6.3	5.6	6.1	6.2	5.7	4.8	5.2	5.2	6.0
SD	1.6	1.7	2.0	1.6	1.8	1.7	2.0	1.6	1.9	1.8	1.5	1.6

(Continued)



**TABLE 2 - CONSUMER PANEL SCORES OF COMMERCIAL FRUIT PRODUCTS** (Continued)

**d. Texture**

9	6	3	2	2	1	2	2	1	0	0	1	0
8	12	3	2	6	6	3	7	0	2	1	0	5
7	8	7	3	4	7	6	14	8	5	6	7	4
6	7	7	5	3	5	9	5	9	3	6	9	9
5	3	9	8	7	6	4	4	6	8	3	5	5
4	1	3	8	6	6	4	1	10	9	10	8	9
3	0	3	3	5	4	1	3	1	4	6	6	5
2	0	1	4	2	1	5	0	0	3	5	1	0
1	0	0	1	1	0	2	0	1	2	0	0	0
N	36	36	36	36	36	36	36	36	36	37	37	37
Mean	7.2	5.8	4.9	5.3	5.7	5.3	6.5	5.4	4.6	4.6	5.4	5.4
SD	1.3	1.8	2.0	2.2	1.8	2.2	1.6	1.5	1.8	1.8	1.7	1.6

Table 3 is the data analysis for the consumer panel sensory scores.

**TABLE 3 - DATA ANALYSIS FOR CONSUMER PANEL SCORES OF COMMERCIAL FRUIT PRODUCTS FOR EFFECT OF STORAGE**

Product	Characteristic							
	Overall		Flavor		Color		Texture	
	F	Sign.	F	Sign.	F	Sign.	F	Sign.
A	10.5	0.01	0.7	nsd	1.9	nsd	3.6	nsd
B	4.7	0.05	2.9	nsd	4.1	0.05	3.0	nsd
C	0.7	nsd	0.1	nsd	0.0	nsd	1.2	nsd
D	0.5	nsd	1.6	nsd	9.6	0.01	4.4	nsd
E	7.7	0.01	1.3	nsd	1.8	nsd	3.5	nsd
F	2.3	nsd	0.1	nsd	0.6	nsd	0.1	nsd

The overall acceptability of the cherries (A) was significantly less upon storage, but as it was greater than 5.5 it was still acceptable.

The blueberries (B) had a significant lowering of each characteristic, including the overall acceptability, with storage. They were still acceptable.

The strawberries (C) had lower ratings than all the other products. There were no significant differences due to storage.

The mango flavored apple cubes (D) had a significant color change with storage. None of the other characteristics significantly changed.

The overall acceptability of the passion fruit/cherry flavored apple cubes (E) decreased with storage to the point of becoming less than acceptable. There were no other significant differences.

The flavored apple slices (F) showed no significant differences with storage.

**Physical Analyses**

Because we are interested in the overall trends in the changes with the physical tests, all the data was smoothed, ie the data was transformed by selecting the median of three consecutive data points. The smoothed data is used in the figures and for the data analysis. However, both the measured and smoothed data is given in the tables.

### Water Activity ( $A_w$ )

Table 4 contains the water activity data. They are plotted in Figure 1.

**TABLE 4- WATER ACTIVITY OF COMMERCIAL FRUIT PRODUCTS**

Product	Storage Data		Storage Time, Months							
	Temp. °C	Description	0	1	3	6	9	12	18	24
A	40	smoothed	0.61	0.61	0.57	0.57	0.62	0.62	0.62	0.60
A	40	actual	0.61	0.62	0.57	0.57	0.65	0.62	0.60	0.63
A	70	smoothed	0.61	0.61	0.57	0.57	0.58	0.58	0.57	0.55
A	70	actual	0.61	0.62	0.54	0.57	0.58	0.58	0.55	0.57
A	100	smoothed	0.61	0.61	0.46	0.43	0.35	0.35	0.37	0.37
A	100	actual	0.61	0.64	0.43	0.46	0.35	0.37	0.26	0.38
B	40	smoothed	0.61	0.61	0.52	0.52	0.54	0.54	0.54	0.50
B	40	actual	0.61	0.64	0.48	0.52	0.54	0.58	0.50	0.59
B	70	smoothed	0.61	0.61	0.50	0.50	0.50	0.50	0.50	0.46
B	70	actual	0.61	0.61	0.47	0.50	0.50	0.55	0.46	0.55
B	100	smoothed	0.61	0.61	0.41	0.41	0.37	0.37	0.37	0.22
B	100	actual	0.61	0.68	0.41	0.41	0.29	0.37	0.22	0.37
C	40	smoothed	0.61	0.61	0.57	0.57	0.57	0.54	0.54	0.51
C	40	actual	0.61	0.66	0.49	0.57	0.54	0.58	0.51	0.61
C	70	smoothed	0.61	0.61	0.57	0.57	0.57	0.53	0.53	0.49
C	70	actual	0.61	0.61	0.62	0.57	0.53	0.57	0.49	0.56
C	100	smoothed	0.61	0.61	0.44	0.40	0.40	0.40	0.40	0.24
C	100	actual	0.61	0.62	0.39	0.44	0.30	0.40	0.24	0.42
D	40	smoothed	0.44	0.44	0.34	0.34	0.34	0.34	0.40	0.40
D	40	actual	0.44	0.45	0.28	0.34	0.34	0.40	0.34	0.43
D	70	smoothed	0.44	0.44	0.36	0.36	0.36	0.36	0.36	0.33
D	70	actual	0.44	0.46	0.27	0.36	0.33	0.40	0.33	0.41
D	100	smoothed	0.44	0.44	0.32	0.32	0.32	0.26	0.26	0.25
D	100	actual	0.44	0.45	0.26	0.32	0.26	0.35	0.25	0.35
E	40	smoothed	0.46	0.46	0.35	0.35	0.37	0.37	0.42	0.42
E	40	actual	0.46	0.50	0.28	0.35	0.37	0.42	0.33	0.47
E	70	smoothed	0.46	0.43	0.38	0.38	0.38	0.38	0.38	0.34
E	70	actual	0.46	0.43	0.27	0.38	0.34	0.42	0.34	0.44
E	100	smoothed	0.46	0.46	0.31	0.31	0.31	0.25	0.25	0.22
E	100	actual	0.46	0.46	0.25	0.31	0.25	0.36	0.22	0.36
F	40	smoothed	0.49	0.49	0.33	0.32	0.32	0.32	0.32	0.31
F	40	actual	0.49	0.50	0.26	0.33	0.32	0.41	0.31	0.44
F	70	smoothed	0.49	0.44	0.35	0.35	0.35	0.33	0.33	0.32
F	70	actual	0.49	0.44	0.26	0.35	0.33	0.41	0.32	0.42
F	100	smoothed	0.49	0.46	0.31	0.31	0.31	0.31	0.31	0.22
F	100	actual	0.49	0.46	0.24	0.31	0.23	0.35	0.22	0.35

There is a general lessening of water activity with storage time and temperature. It is particularly noticeable at 100 °F.

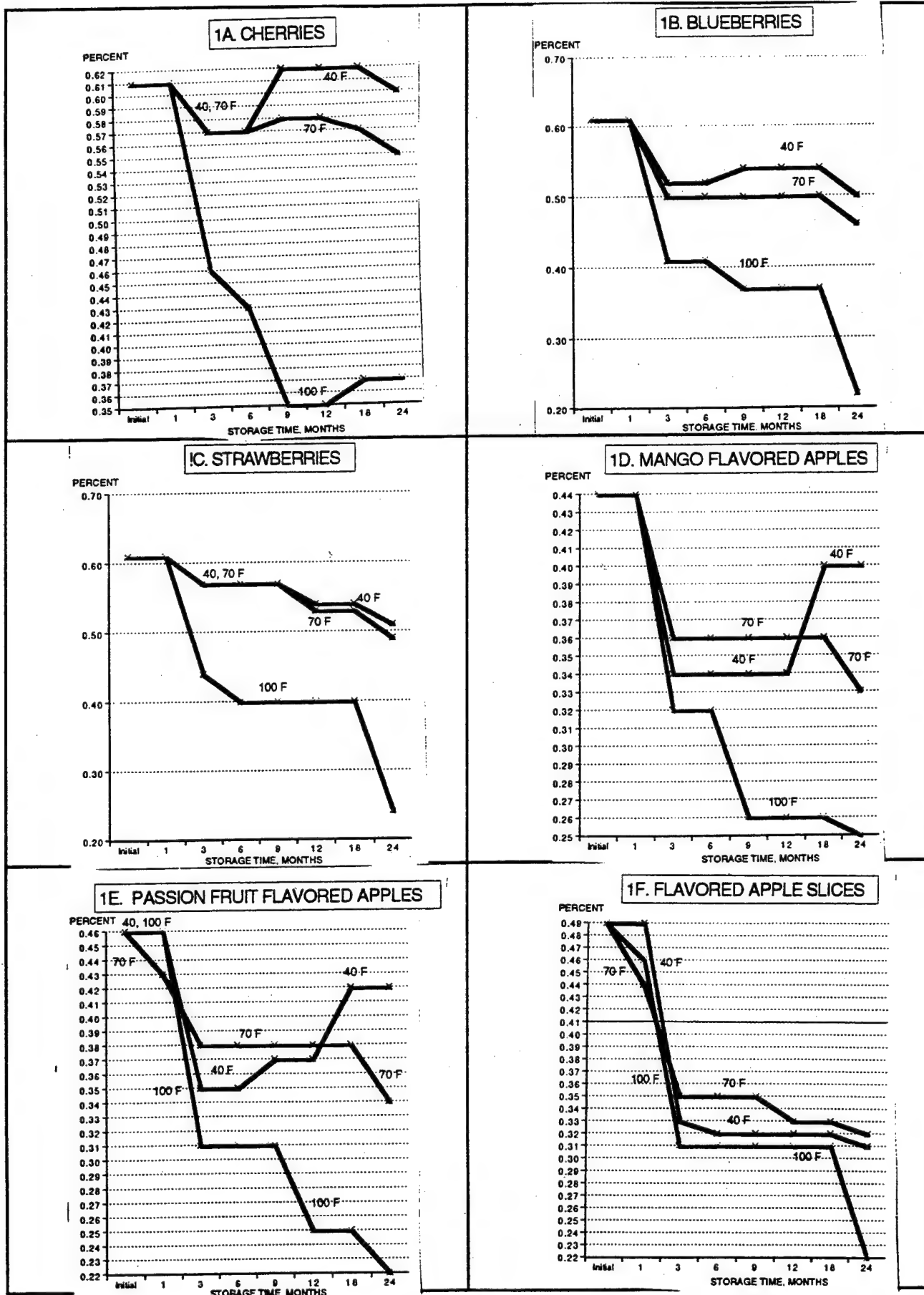


Fig. 1 - WATER ACTIVITY OF COMMERCIAL FRUIT PRODUCTS

### Percent Moisture - Vacuum Oven Method

Table 5 contains the moisture content data as determined by the vacuum oven method. They are plotted in Figure 2.

**TABLE 5 - MOISTURE CONTENT OF COMMERCIAL FRUIT PRODUCTS  
(VACUUM OVEN METHOD)**

Product	Storage Data		Storage Time, Months							
	Temp. °C	Description	0	1	3	6	9	12	18	24
A	40	smoothed	17.0	17.6	17.6	17.5	17.5	17.5	18.2	18.2
A	40	actual	17.0	18.2	17.6	17.0	17.5	17.5	18.3	18.2
A	70	smoothed	17.0	17.7	17.7	17.1	16.2	16.1	16.1	15.0
A	70	actual	17.0	17.8	17.7	17.1	16.2	16.1	16.1	15.0
A	100	smoothed	17.0	16.6	16.6	15.2	7.6	6.4	3.4	3.3
A	100	actual	17.0	16.6	15.2	16.9	7.6	6.4	3.4	3.3
B	40	smoothed	19.9	15.0	15.0	15.6	16.2	17.7	17.7	15.4
B	40	actual	19.9	14.7	15.0	15.6	16.2	17.7	17.8	15.4
B	70	smoothed	19.9	16.1	15.8	15.7	14.3	14.3	14.3	12.6
B	70	actual	19.9	16.1	15.7	15.8	14.3	14.3	14.9	12.6
B	100	smoothed	19.9	15.0	14.2	8.8	6.4	4.9	3.0	2.9
B	100	actual	19.9	15.0	14.2	8.8	6.4	4.9	3.0	2.9
C	40	smoothed	13.8	14.6	15.8	15.8	15.8	15.3	15.3	15.3
C	40	actual	13.8	16.0	14.6	15.8	16.0	14.6	15.3	15.4
C	70	smoothed	13.8	15.8	15.8	15.5	14.7	14.4	13.4	12.1
C	70	actual	13.8	16.1	15.8	15.5	14.4	14.7	13.4	12.1
C	100	smoothed	13.8	13.8	13.0	10.0	6.9	5.6	2.5	1.4
C	100	actual	13.8	14.3	13.0	10.0	6.9	5.6	1.4	2.5
D	40	smoothed	8.1	5.9	5.9	6.8	6.8	7.0	7.3	7.3
D	40	actual	8.1	5.9	5.9	6.8	6.8	7.0	7.3	8.3
D	70	smoothed	8.1	6.9	6.9	7.0	7.0	7.0	7.0	6.9
D	70	actual	8.1	5.9	6.9	7.0	7.2	7.0	7.4	6.9
D	100	smoothed	8.1	6.0	5.5	4.4	3.6	2.4	2.4	2.4
D	100	actual	8.1	5.5	6.0	4.4	3.6	0.2	2.4	2.9
E	40	smoothed	9.6	7.7	7.7	8.0	8.1	8.1	8.9	8.9
E	40	actual	9.6	7.7	7.7	8.0	8.1	8.1	8.9	9.1
E	70	smoothed	9.6	8.6	8.6	8.7	8.7	8.7	8.7	8.6
E	70	actual	9.6	7.5	8.6	8.8	8.7	8.7	8.6	8.7
E	100	smoothed	9.6	7.5	7.4	6.0	4.6	2.8	2.8	2.8
E	100	actual	9.6	7.5	7.4	6.0	4.6	0.2	2.8	3.1
F	40	smoothed	7.8	6.5	6.5	6.8	6.8	8.7	9.4	9.4
F	40	actual	7.8	6.4	6.5	6.8	6.9	8.7	9.4	10.7
F	70	smoothed	7.8	7.3	7.3	7.4	7.8	7.9	8.3	8.3
F	70	actual	7.8	7.3	6.2	7.4	7.8	7.9	8.9	8.3
F	100	smoothed	7.8	6.9	6.2	4.2	4.1	3.5	3.4	3.0
F	100	actual	7.8	6.2	6.9	4.2	3.5	4.1	3.4	3.0

There is a general slight decrease in the percent moisture with storage time and temperature. There is a large decrease at 100°F.

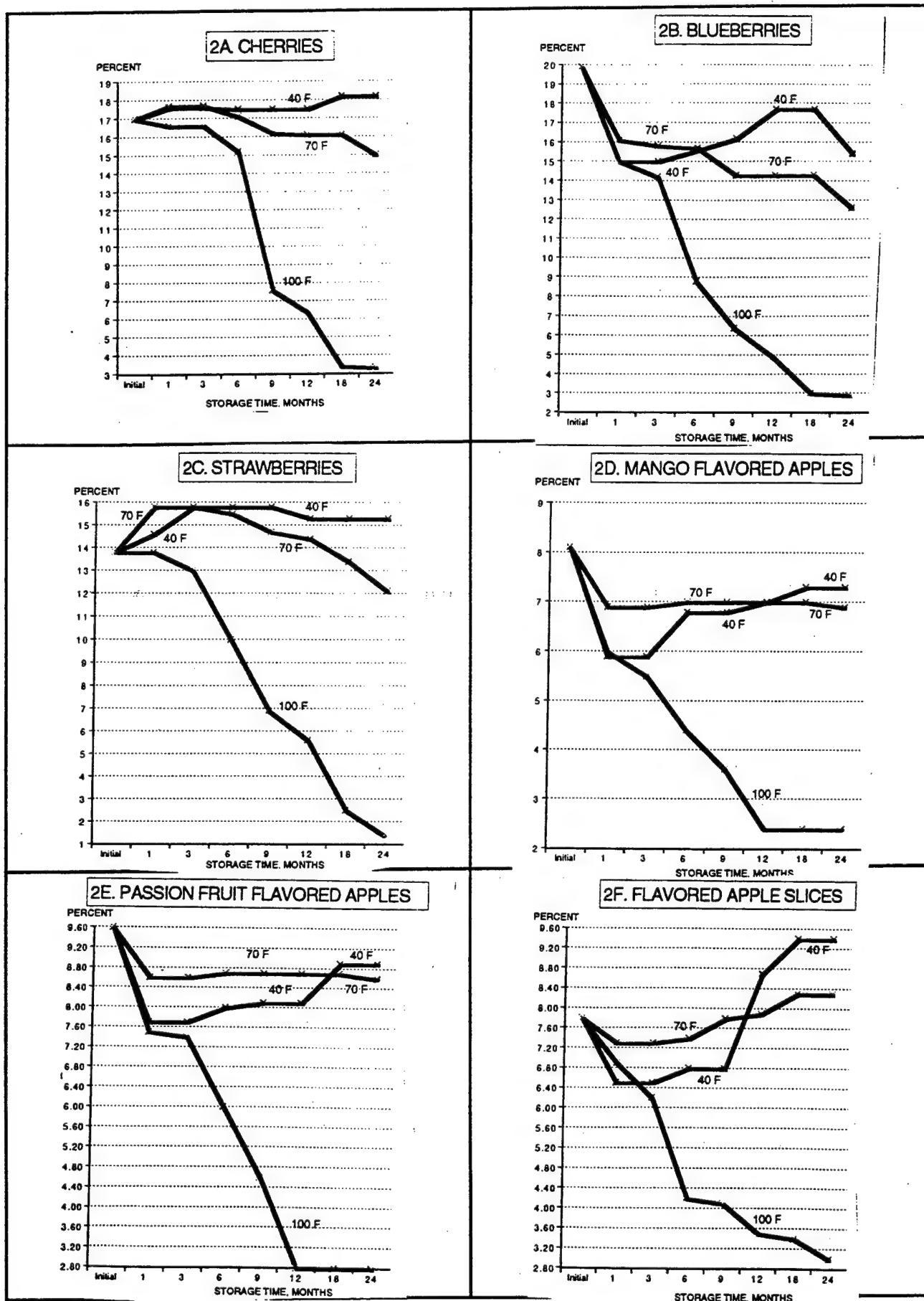


Fig. 2 - VACUUM OVEN METHOD OF MOISTURE ANALYSIS OF COMMERCIAL FRUIT PRODUCTS

# Percent Moisture - Radiant Heating Method

Table 6 contains the moisture content data as determined by the radiant heating method. They are plotted in Figure 3.

**TABLE 6 - PERCENT MOISTURE OF COMMERCIAL FRUIT PRODUCTS**  
**- RADIANT HEATING METHOD**

Product	Storage Data		Storage Time, Months							
	Temp. °C	Description	0	1	3	6	9	12	18	24
A	40	smoothed	25.6	25.6	25.6	25.6	25.6	24.2	21.4	19.6
A	40	actual	25.6	27.4	24.8	28.2	24.2	25.7	21.4	19.6
A	70	smoothed	25.6	26.7	26.7	24.5	20.0	17.6	15.4	15.3
A	70	actual	25.6	26.7	27.1	24.5	20.0	15.4	17.6	15.3
A	100	smoothed	25.6	25.0	24.5	24.5	17.2	17.2	0.6	0.2
A	100	actual	25.6	25.0	24.5	16.9	29.0	17.2	0.2	0.6
B	40	smoothed	26.9	26.9	19.8	19.2	16.9	16.4	13.4	12.6
B	40	actual	26.9	19.8	26.9	19.2	16.4	16.9	13.4	12.6
B	70	smoothed	26.9	26.5	21.8	16.5	15.4	15.4	12.3	11.0
B	70	actual	26.9	21.8	26.5	16.5	15.4	15.4	11.0	12.3
B	100	smoothed	26.9	22.8	20.2	9.8	6.1	6.1	0.4	0.1
B	100	actual	26.9	20.2	22.0	9.8	6.1	6.1	0.1	0.4
C	40	smoothed	22.2	25.8	25.8	22.8	22.8	22.6	16.9	13.7
C	40	actual	22.2	25.8	26.7	22.8	23.1	22.6	13.7	16.9
C	70	smoothed	22.2	25.9	25.9	23.6	23.6	23.6	17.8	16.2
C	70	actual	22.2	25.9	26.3	22.0	23.6	23.9	16.2	17.8
C	100	smoothed	22.2	22.2	20.4	18.1	10.3	0.5	0.1	0.1
C	100	actual	22.2	23.0	20.4	18.1	10.3	0.5	0.1	0.1
D	40	smoothed	10.4	8.1	8.1	8.1	9.7	9.7	9.4	8.1
D	40	actual	10.4	7.5	8.1	8.1	9.7	9.7	8.1	9.4
D	70	smoothed	10.4	8.8	8.8	9.2	9.2	9.2	7.8	7.0
D	70	actual	10.4	7.6	8.8	9.4	9.2	9.4	7.0	7.8
D	100	smoothed	10.4	7.1	7.1	7.1	6.6	6.6	3.5	3.5
D	100	actual	10.4	7.1	7.1	6.0	10.2	6.6	0.2	3.5
E	40	smoothed	18.4	14.8	14.8	16.4	16.4	16.4	15.5	13.1
E	40	actual	18.4	14.8	13.7	16.4	18.2	16.4	13.1	15.5
E	70	smoothed	18.4	14.5	14.5	16.8	16.8	16.3	14.0	12.0
E	70	actual	18.4	14.4	14.5	16.8	18.3	16.3	14.0	12.0
E	100	smoothed	18.4	14.5	14.4	13.4	13.3	11.6	10.1	10.1
E	100	actual	18.4	14.4	14.5	13.3	13.4	11.6	0.2	10.1
F	40	smoothed	14.0	11.5	11.5	14.3	14.8	14.8	10.8	9.7
F	40	actual	14.0	11.5	11.1	14.3	15.3	14.8	9.7	10.8
F	70	smoothed	14.0	13.0	13.0	12.6	12.6	12.6	12.6	8.5
F	70	actual	14.0	13.0	12.0	15.0	12.6	12.7	8.5	13.8
F	100	smoothed	14.0	11.1	10.5	10.5	9.8	9.8	4.7	4.1
F	100	actual	14.0	11.1	10.5	9.8	10.7	9.8	4.1	4.7

This data follows the same trends as with the vacuum oven method but the losses are greater at 40 and 70 °F.

The water activity and radiant heating percent moisture had a correlation  $r$  of 0.699. The water activity; and vacuum oven percent moisture had a correlation  $r$  of

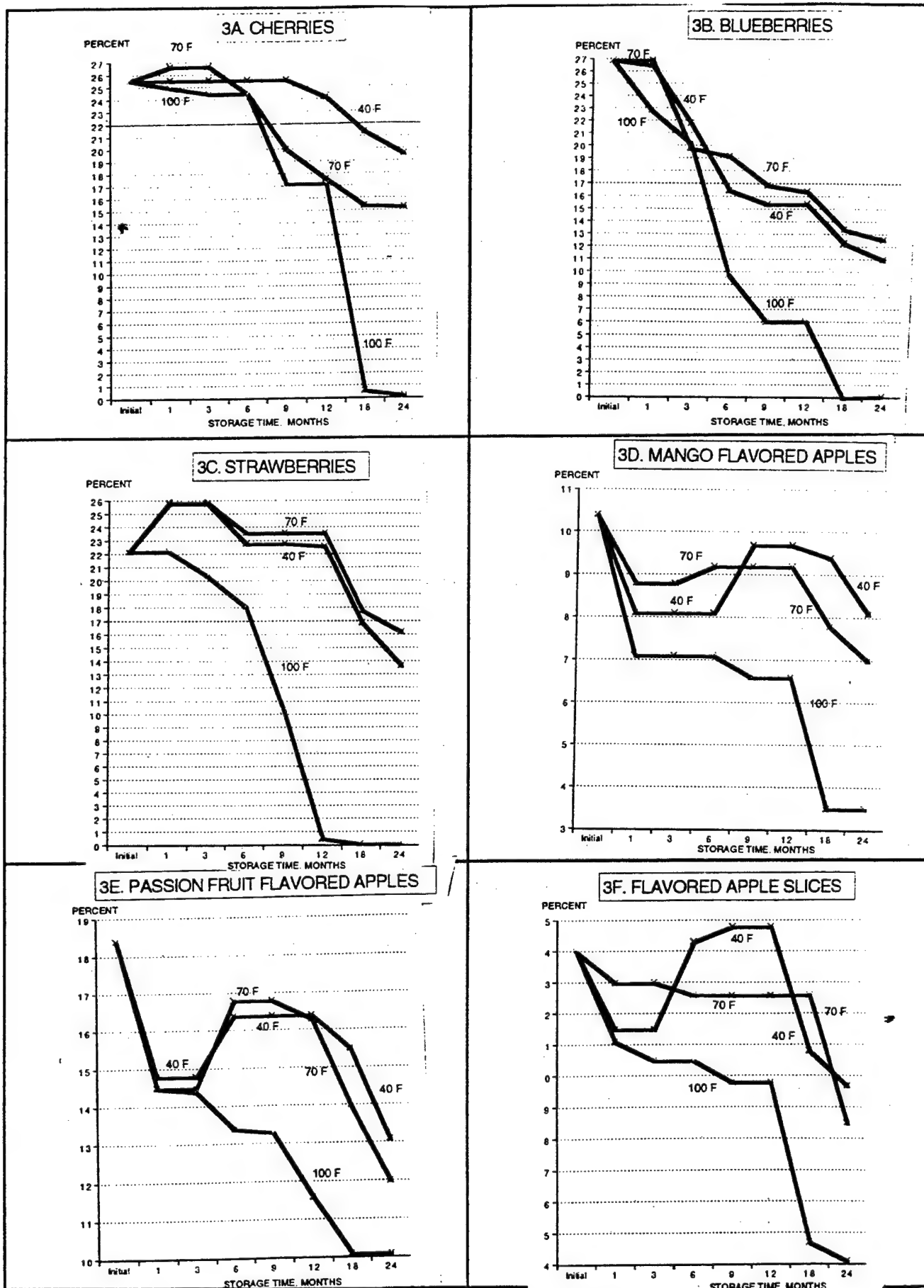


Fig. 3 - RADIANT HEATING METHOD OF MOISTURE ANALYSIS OF COMMERCIAL FRUIT PRODUCTS

0.837. The two methods of measuring percent moisture correlated at an  $r$  of 0.816. These correlations were all significant at a probability level greater than 99.99%.

### Reflectance Color

#### L Values

Table 7 contains the reflectance L values. They are plotted in Figure 4.

**TABLE 7 - REFLECTANCE L VALUES OF COMMERCIAL FRUIT PRODUCTS**

Product	Storage Data		Storage Time, Months							
	Temp. °C	Description	0	1	3	6	9	12	18	24
A	40	smoothed	19.1	19.1	18.9	18.9	17.5	17.5	17.5	17.5
A	40	actual	19.1	31.5	18.9	15.1	21.8	16.6	17.5	17.9
A	70	smoothed	19.1	20.2	20.2	18.7	18.4	18.4	17.6	16.5
A	70	actual	19.1	20.2	20.3	16.5	18.7	18.4	17.6	16.5
A	100	smoothed	19.1	19.1	17.7	15.9	15.9	17.1	17.4	17.4
A	100	actual	19.1	21.1	17.7	13.0	15.9	17.1	18.8	17.4
B	40	smoothed	18.5	19.1	19.1	19.1	16.4	16.4	16.4	16.4
B	40	actual	18.5	30.2	19.1	10.8	19.6	15.9	16.4	16.7
B	70	smoothed	18.5	19.6	19.6	17.2	17.2	18.1	18.1	17.6
B	70	actual	18.5	19.6	21.3	9.5	17.2	19.7	18.1	17.6
B	100	smoothed	18.5	18.9	18.9	18.3	18.3	19.9	19.9	18.8
B	100	actual	18.5	21.4	18.9	13.0	18.3	19.9	20.8	18.8
C	40	smoothed	18.9	20.4	20.4	18.5	18.5	18.5	17.5	17.2
C	40	actual	18.9	33.7	20.4	12.0	18.5	18.6	17.5	17.2
C	70	smoothed	18.9	20.9	20.9	18.4	18.4	19.1	19.3	19.3
C	70	actual	18.9	20.9	21.3	14.3	18.4	19.3	19.1	19.3
C	100	smoothed	18.9	19.7	19.7	19.4	19.4	19.4	19.2	19.2
C	100	actual	18.9	21.1	19.7	12.7	19.4	17.9	19.8	19.2
D	40	smoothed	43.5	43.5	42.5	42.5	42.5	40.9	40.9	40.9
D	40	actual	43.5	61.4	41.0	42.5	42.7	39.7	40.9	42.8
D	70	smoothed	43.5	40.7	40.5	40.5	38.4	38.4	38.0	35.8
D	70	actual	43.5	40.7	40.5	35.4	41.7	38.4	35.8	38.0
D	100	smoothed	43.5	40.2	38.6	34.4	34.4	34.4	32.8	31.8
D	100	actual	43.5	40.2	38.6	33.5	34.4	32.8	34.9	31.8
E	40	smoothed	27.1	28.1	28.1	25.4	25.4	26.1	26.1	26.1
E	40	actual	27.1	40.0	28.1	24.8	25.4	27.1	26.1	27.9
E	70	smoothed	27.1	28.0	28.0	25.4	24.6	24.6	24.5	24.2
E	70	actual	27.1	28.4	28.0	21.2	25.4	24.5	24.6	24.2
E	100	smoothed	27.1	24.8	23.5	21.2	20.2	20.2	20.2	20.2
E	100	actual	27.1	24.8	23.5	15.8	21.2	19.9	20.2	20.7
F	40	smoothed	34.1	36.8	36.8	36.8	36.9	36.9	36.9	30.0
F	40	actual	34.1	51.0	36.8	37.4	34.1	36.9	40.5	30.0
F	70	smoothed	34.1	35.1	35.1	32.7	32.7	33.9	37.8	37.8
F	70	actual	34.1	41.6	35.1	31.7	32.7	33.9	37.8	38.6
F	100	smoothed	34.1	34.1	31.8	26.8	26.8	26.8	26.8	26.8
F	100	actual	34.1	31.8	34.1	26.8	24.5	26.8	28.2	20.4

There is a general decrease in the L values with storage time indicating a darkening of the products. There is also a darkening with storage temperature of



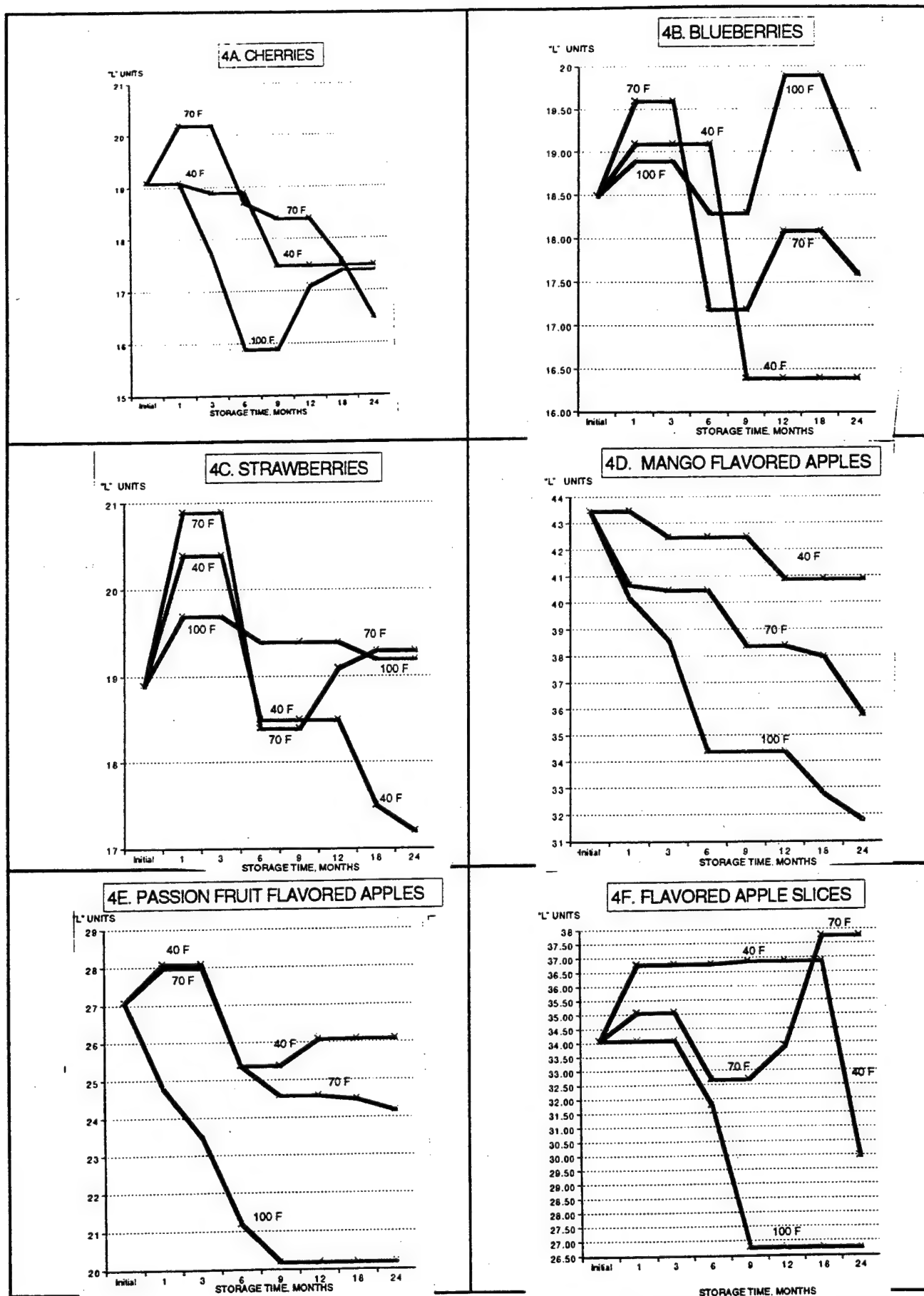


Fig. 4 - REFLECTANCE L VALUES OF COMMERCIAL FRUIT PRODUCTS

100 °F except with the blueberries and strawberries.

### a Values

Table 8 contains the reflectance color a values (red and green). They are plotted in Figure 5.

**TABLE 8 - REFLECTANCE - a VALUES OF COMMERCIAL FRUIT PRODUCTS**

Product	Storage Data		Storage Time, Months							
	Temp. °C	Description	0	1	3	6	9	12	18	24
A	40	smoothed	5.6	5.6	5.6	5.6	5.8	5.8	5.9	5.9
A	40	actual	5.6	9.6	4.5	5.6	5.4	5.8	5.9	6.0
A	70	smoothed	5.6	4.6	4.6	4.6	3.8	2.0	2.0	1.8
A	70	actual	5.6	4.6	4.6	6.5	3.8	2.0	2.0	1.8
A	100	smoothed	5.6	2.3	2.3	1.5	0.4	0.1	0.1	-0.1
A	100	actual	5.6	2.3	1.5	2.6	0.4	0.1	0.1	-0.1
B	40	smoothed	0.2	0.3	0.3	0.3	0.2	-0.1	-0.1	-0.1
B	40	actual	0.2	0.2	0.2	2.5	0.3	-0.1	-0.1	-0.1
B	70	smoothed	0.2	0.2	0.2	0.3	0.3	-0.1	-0.1	-0.1
B	70	actual	0.2	0.2	0.2	2.9	0.3	-0.1	-0.1	0.0
B	100	smoothed	0.2	0.2	0.2	0.3	0.3	-0.1	-0.1	-0.1
B	100	actual	0.2	0.1	0.2	1.9	0.3	-0.2	-0.1	-0.1
C	40	smoothed	1.8	2.2	2.2	2.2	1.9	1.9	1.4	1.4
C	40	actual	1.8	2.2	2.2	6.1	1.9	1.3	2.0	1.4
C	70	smoothed	1.8	1.8	1.9	1.9	1.2	1.1	0.8	0.7
C	70	actual	1.8	1.6	1.9	3.6	1.2	0.8	1.1	0.7
C	100	smoothed	1.8	0.9	0.9	1.3	1.3	0.8	0.8	0.8
C	100	actual	1.8	0.9	0.9	1.3	1.3	0.6	0.8	0.8
D	40	smoothed	8.6	8.6	8.6	8.6	8.0	7.4	7.4	6.9
D	40	actual	8.6	12.7	7.9	9.6	8.0	7.4	6.9	7.4
D	70	smoothed	8.6	8.0	8.0	8.4	8.4	7.3	7.3	7.3
D	70	actual	8.6	8.0	7.4	8.7	8.4	7.2	7.3	8.9
D	100	smoothed	8.6	9.0	9.1	9.1	8.4	8.4	8.9	8.9
D	100	actual	8.6	9.1	9.0	10.3	8.4	7.9	8.9	9.0
E	40	smoothed	10.5	10.7	10.7	10.7	10.1	9.4	9.4	9.4
E	40	actual	10.5	13.9	10.7	13.5	10.1	8.9	9.4	9.6
E	70	smoothed	10.5	9.7	9.7	9.1	6.9	6.7	6.5	5.9
E	70	actual	10.5	9.7	9.1	12.7	6.9	6.5	6.7	5.9
E	100	smoothed	10.5	7.5	7.5	6.1	3.9	3.0	3.0	2.8
E	100	actual	10.5	7.5	6.1	7.7	2.9	3.9	2.8	3.0
F	40	smoothed	12.1	12.8	12.8	12.5	11.2	11.2	11.1	8.2
F	40	actual	12.1	17.8	12.8	12.5	11.2	11.1	12.6	8.2
F	70	smoothed	12.1	11.8	11.4	11.1	10.3	10.3	10.3	9.7
F	70	actual	12.1	11.4	11.8	11.1	10.3	10.3	11.1	9.7
F	100	smoothed	12.1	9.3	9.3	9.3	7.3	7.3	7.3	6.7
F	100	actual	12.1	9.1	9.3	10.7	5.2	7.3	6.7	7.8

There is a general decrease in these values with both storage time and temperature. The mango flavored apple cubes did have greater values at 100 °F when

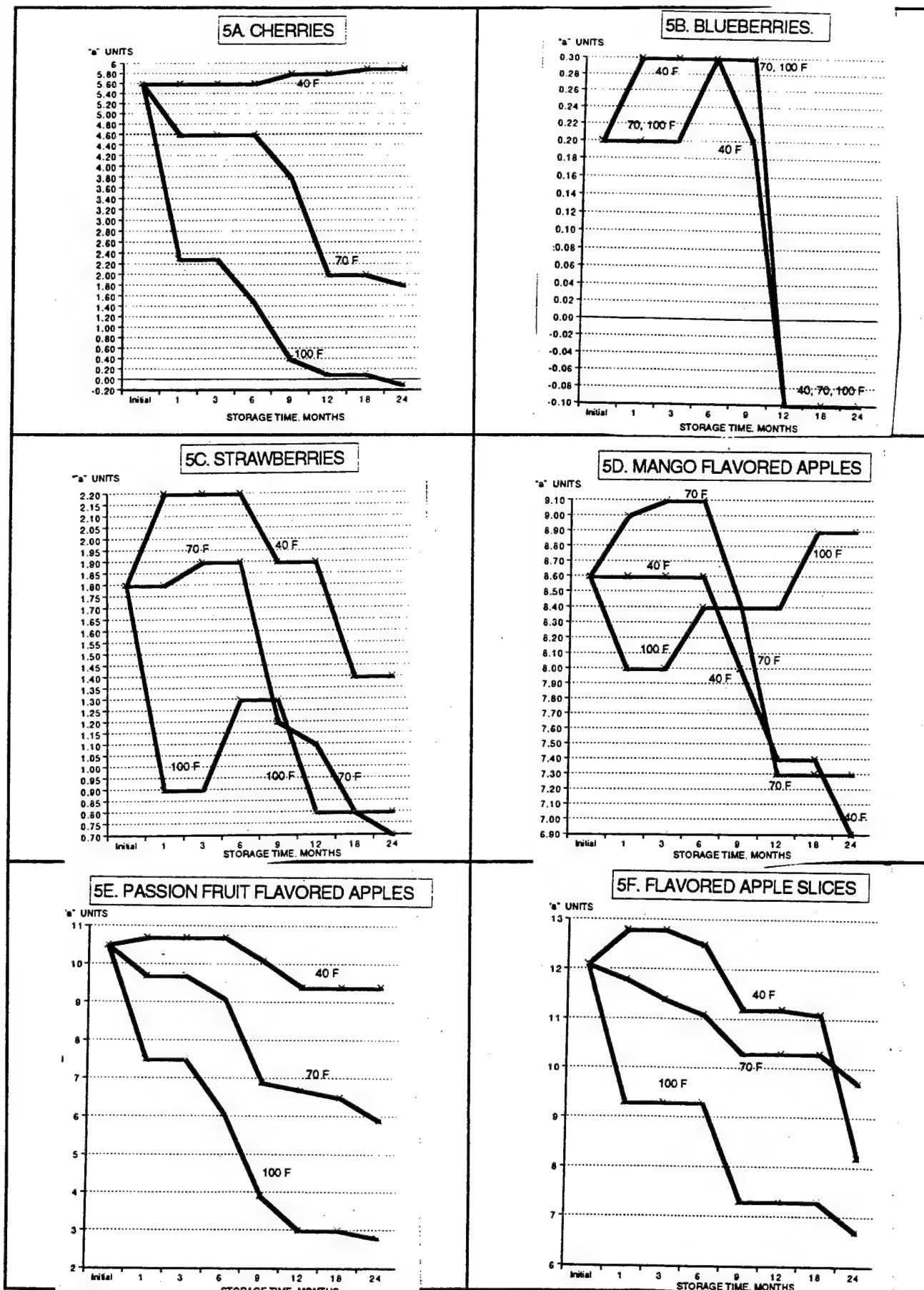


Fig. 5 - REFLECTANCE a VALUES OF COMMERCIAL FRUIT PRODUCTS

compared to the lower storage temperatures. This indicates a tendency to increase in red color.

**b values**

Table 9 contains the reflectance b values (blue and yellow). They are plotted in Figure 6.

**TABLE 9 - REFLECTANCE - b VALUES OF COMMERCIAL FRUIT PRODUCTS**

Product	Storage Temp. °C	Data Description	Storage Time, Months							
			0	1	3	6	9	12	18	24
A	40	smoothed	1.9	1.9	1.9	1.9	2.6	2.6	2.6	2.6
A	40	actual	1.9	3.2	0.9	3.7	1.6	2.7	2.6	2.7
A	70	smoothed	1.9	2.1	2.1	2.2	2.2	1.5	1.2	1.2
A	70	actual	1.9	2.2	2.1	3.2	2.2	0.6	1.5	1.2
A	100	smoothed	1.9	0.8	0.7	0.6	-0.3	-0.3	-0.5	-0.5
A	100	actual	1.9	0.8	0.7	0.6	-0.3	-0.6	-0.2	-0.5
B	40	smoothed	-0.8	-0.8	-1.0	-1.0	-0.9	-0.9	-0.9	-0.9
B	40	actual	-0.8	-1.3	-0.7	-1.0	-0.9	-0.5	-1.0	-0.9
B	70	smoothed	-0.8	-0.5	-0.5	-0.5	-0.5	-0.5	-0.6	-0.6
B	70	actual	-0.8	-0.5	-0.4	-1.0	-0.5	-0.6	-0.4	-0.8
B	100	smoothed	-0.8	-0.6	-0.6	-0.6	-0.6	-0.6	-0.9	-0.9
B	100	actual	-0.8	-0.6	-0.4	-0.7	-0.6	-0.9	-0.2	-0.9
C	40	smoothed	0.9	0.9	1.0	1.0	0.7	0.7	0.6	0.6
C	40	actual	0.9	0.9	1.0	3.0	0.7	0.4	0.9	0.6
C	70	smoothed	0.9	0.9	1.4	1.4	0.6	0.6	0.6	0.6
C	70	actual	0.9	0.7	1.4	1.5	0.6	0.4	1.2	0.6
C	100	smoothed	0.9	0.9	0.9	0.9	0.7	0.7	0.7	0.7
C	100	actual	0.9	0.4	0.9	1.5	0.7	0.3	0.7	0.7
D	40	smoothed	16.2	16.2	16.2	16.0	16.0	15.0	15.0	15.0
D	40	actual	16.2	21.9	15.0	16.6	16.0	14.4	15.0	15.8
D	70	smoothed	16.2	14.2	14.2	15.1	15.1	13.3	13.3	12.7
D	70	actual	16.2	14.2	14.2	15.1	15.5	13.3	12.7	14.3
D	100	smoothed	16.2	14.8	14.7	14.7	12.1	12.1	11.7	11.5
D	100	actual	16.2	14.4	14.8	14.7	12.1	11.7	12.1	11.5
E	40	smoothed	7.5	7.9	7.9	7.9	7.2	7.2	7.3	7.3
E	40	actual	7.5	9.5	7.9	9.6	7.2	6.7	7.3	7.9
E	70	smoothed	7.5	7.5	7.5	7.5	5.3	5.3	5.0	5.0
E	70	actual	7.5	7.0	7.5	9.4	5.3	4.9	6.1	5.0
E	100	smoothed	7.5	6.0	4.8	4.5	2.9	2.2	2.2	2.1
E	100	actual	7.5	6.0	4.8	4.5	1.8	2.9	2.2	2.1
F	40	smoothed	11.1	11.9	11.9	11.9	11.6	11.6	11.6	8.3
F	40	actual	11.1	15.1	11.9	13.7	11.5	11.6	14.8	8.3
F	70	smoothed	11.1	11.4	11.4	11.4	11.7	13.1	13.3	13.3
F	70	actual	11.1	14.2	11.4	11.7	11.2	13.1	13.9	13.3
F	100	smoothed	11.1	11.1	11.3	11.3	7.3	7.3	7.3	7.1

With most products there was a general lessening of the b values with both storage time and temperature. This indicates an increase in blue color.

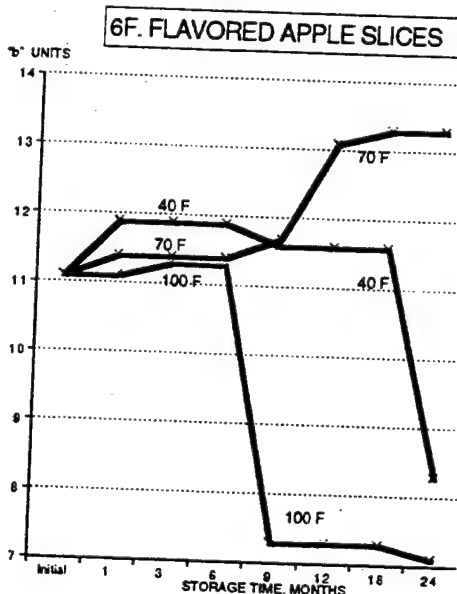
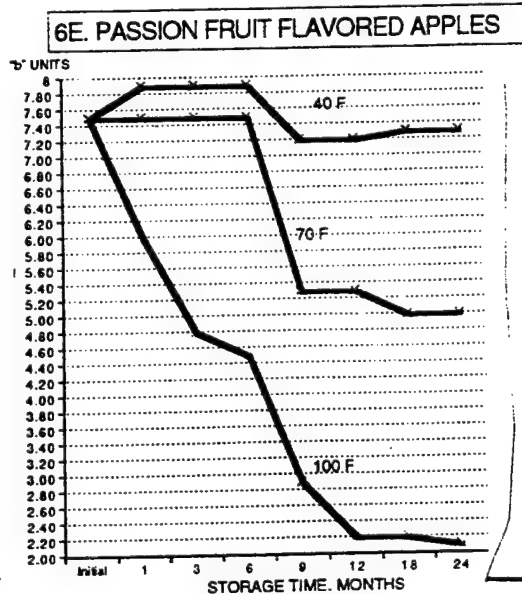
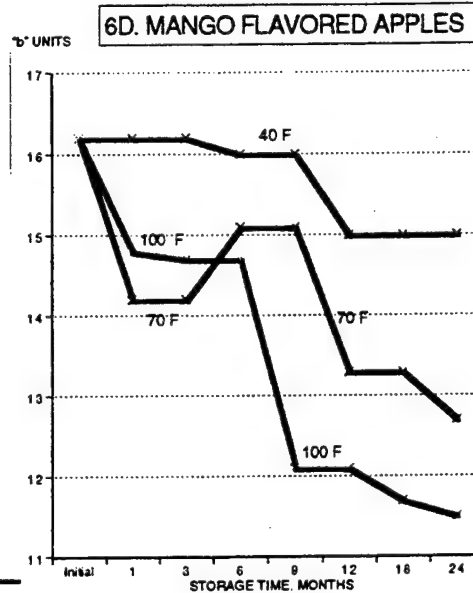
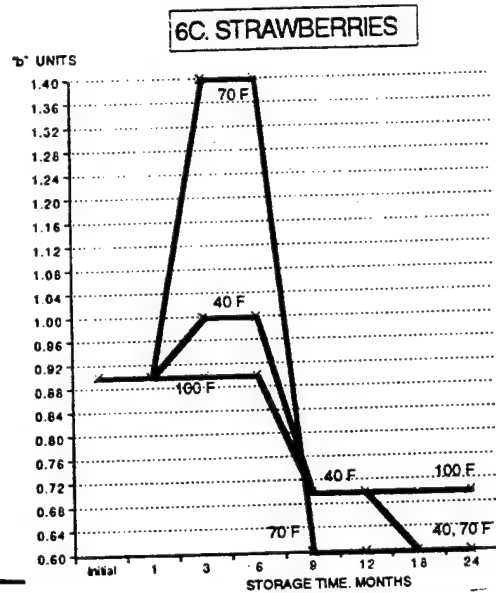
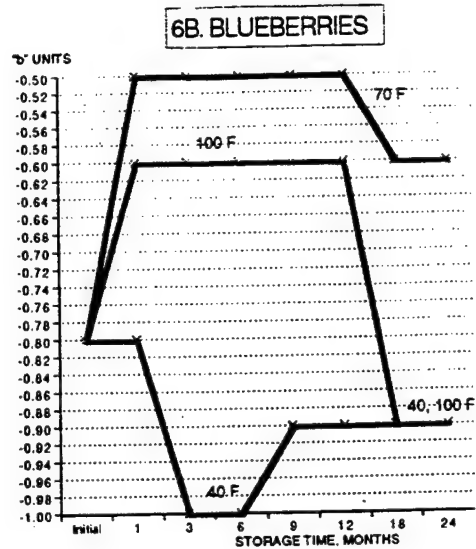
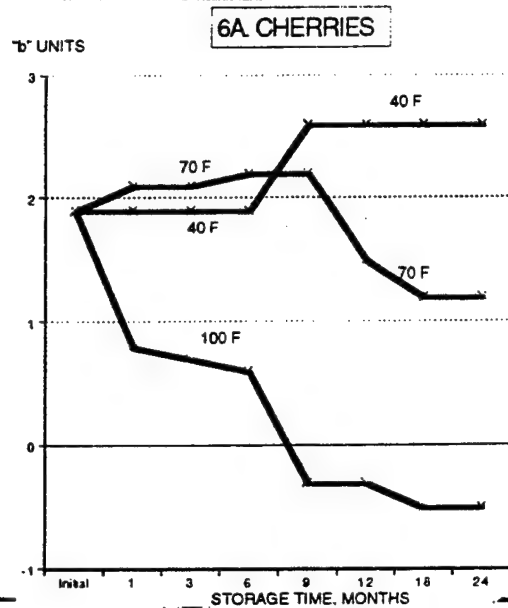


Fig. 6 - REFLECTANCE  $b^*$  VALUES OF COMMERCIAL FRUIT PRODUCTS

## Data Analysis

Analysis of variance was done to the smoothed data with factors of storage time, storage temperature and the interaction of time and temperature. It used data that was transformed as a deviation from the initial values. This analysis is presented in Table 10.

**TABLE 10 - DATA ANALYSIS FOR COMMERCIAL FRUIT PRODUCTS**

Product	Factor					
	Time		Temperature		Time x Temperature	
	F	Sign.	F	Sign.	F	Sign.
<b>A. Cherries</b>						
Aw	2.48	nsd	3.21	nsd	5.23	0.05
RH Moisture	4.27	0.05	0.71	nsd	32.8	<0.00001
VO Moisture	8.98	0.01	0.06	nsd	20.9	0.001
L	2.18	nsd	2.22	nsd	0.09	nsd
a	1.66	nsd	39.0	<0.0001	9.07	0.01
b	2.11	nsd	7.24	0.02	2.79	nsd
<b>B. Blueberries</b>						
Aw	2.19	nsd	1.47	nsd	3.42	nsd
RH Moisture	0.40	nsd	1.47	nsd	2.81	nsd
VO Moisture	7.98	0.01	0.94	nsd	17.9	0.0001
L	13.04	0.01	0.17	nsd	8.62	0.01
a	5.64	0.05	0.26	nsd	0.21	nsd
b	0.82	nsd	8.02	0.01	2.21	nsd
<b>C. Strawberries</b>						
Aw	0.16	nsd	2.69	nsd	5.12	0.05
RH Moisture	0.00	nsd	1.46	nsd	3.36	nsd
VO Moisture	6.51	0.02	1.44	nsd	19.0	0.0001
L	12.4	0.01	0.67	0.42	5.98	0.05
a	13.7	0.01	36.4	<0.0000	3.66	nsd
b	2.92	nsd	0.22	nsd	0.34	nsd
<b>D. Mango Flavored Apple Cubes</b>						
Aw	2.76	nsd	0.15	nsd	7.01	0.02
RH Moisture	4.75	0.05	0.26	nsd	11.8	0.01
VO Moisture	6.89	0.02	0.36	nsd	10.1	0.01
L	0.25	nsd	29.4	<0.0000	11.0	0.01
a	3.32	nsd	0.06	nsd	2.64	nsd
b	0.02	nsd	6.58	0.02	4.23	nsd
<b>E. Passionfruit Flavored Apple Cubes</b>						
Aw	2.30	nsd	0.00	nsd	4.03	nsd
RH Moisture	0.01	nsd	1.65	nsd	1.57	nsd
VO Moisture	6.28	0.02	0.07	nsd	10.2	0.01
L	0.28	nsd	11.1	0.01	0.34	nsd
a	0.00	nsd	24.3	0.0001	6.43	0.02
b	0.60	nsd	16.5	0.001	7.30	0.02

(Continued)

**TABLE 10 - DATA ANALYSIS FOR COMMERCIAL FRUIT PRODUCTS**

(Continued)

**F. Flavored Apple Chips**

Aw	0.21	nsd	0.10	nsd	0.42	nsd
RH Moisture	0.27	nsd	0.90	nsd	3.95	nsd
VO Moisture	17.3	0.001	0.00	nsd	17.8	0.001
L	0.06	nsd	6.82	0.02	0.03	nsd
a	8.99	0.01	30.4	<0.0001	1.32	nsd
b	0.02	nsd	0.75	nsd	0.46	nsd

**Conclusions**

Osmotically dried fruits can be satisfactorily prepared. However, there are significant physical changes with both storage time and temperature. This indicated that the commercial package is not acceptable for our use, where a three year shelf-life at 80 °F or six months at 120 °F is required. The next phase tested the Army's barrier package for suitability.

**NUTRIENT ENHANCED FRUIT**

The purpose of this study was two-fold. First was to determine if nutrients, folic acid, magnesium (Mg) and zinc (Zn) could be infused into the fruit during osmosis. Second was to determine if the Army's MRE barrier package would provide acceptable protection to the products. Preliminary data was presented by Cohen and Tucker in a Natick Technical Report (1998) and published in the Proceedings of the 5th Conference of Food Engineering (1997)

Two representative products were chosen for this study. Each one contained either the folic acid or the two minerals. The products are listed in Table 11.

**TABLE 11 - NUTRIENT ENHANCED FRUIT**

<u>Product</u>	<u>Added Nutrients</u>
A. Whole Tart Cherries	Folic Acid
B. Whole Tart Cherries	Mg, Zn (in form of lactate)
C. Whole Tart Cherries	none
D. Mango Flavored Apple Cubes	Folic Acid
E. Mango Flavored Apple Cubes	Mg, Zn (in form of lactate)
F. Mango Flavored Apple Cubes	none

Products A, B, D and E were prepared by CherryCentral. (C and F are included in the table as they were used in sensory comparisons.)

**Packaging**

The products were initially packaged in the transparent polymeric commercial package. Upon receipt at Natick, half of the products were repackaged in the MRE barrier package.

**Storage**

All four products with both packages were stored at 40, 70 and 100 °F with withdrawals at one, three, six, nine, twelve, eighteen and twenty-four months. A

small additional amount was stored at 120 °F and withdrawn after one month for sensory testing

## Results

### Sensory Testing

#### Consumer Panel

The results of both tests (at zero storage time and after one month at 120 °F) are presented in Table 12. For purposes of comparison the scores for the same fruit in the commercial package from the earlier study are included. The samples stored with the barrier package were used for the storage.

**TABLE 12 - CONSUMER PANEL SCORES OF NUTRIENT ENHANCED FRUIT**

Score	Storage Time, Months											
	0			1			0			1		
	Added Nutrient											
	Min.	Vit.	None	Min.	Vit.	None	Min.	Vit.	None	Min.	Vit.	None
	Product											
	Cherries						Mango Flavored Apples					
Number of Scores												
A. Overall Acceptability												
9	3	4	7	3	1	0	1	2	1	1	1	0
8	10	9	9	6	7	5	6	7	7	6	11	8
7	11	9	8	11	12	8	8	9	3	9	6	12
6	5	4	4	7	6	6	6	8	9	7	6	5
5	2	3	4	1	3	7	5	4	8	3	8	7
4	4	7	3	6	6	6	4	3	4	9	3	3
3	1	0	0	1	1	3	4	3	1	3	2	1
2	2	1	1	0	0	1	2	0	2	0	1	1
1	0	0	0	1	1	0	0	0	1	0	0	0
N	36	36	36	38	38	36	36	36	36	38	38	37
mean	6.8	6.6	6.9	6.1	6.1	5.6	5.7	6.3	5.7	5.8	6.2	6.2
SD	1.6	1.7	1.8	2.0	1.8	1.7	1.9	1.7	1.9	1.7	1.7	1.6
B. Flavor												
9	2	3	7	3	2	4	2	4	2	1	2	0
8	12	8	9	6	4	3	7	6	5	8	11	1
7	9	11	5	12	14	15	7	11	3	5	5	6
6	2	4	7	6	5	4	8	8	10	9	8	6
5	4	5	4	2	3	6	4	3	9	3	7	3
4	3	2	1	5	5	2	3	2	4	9	2	10
3	3	3	2	1	3	0	5	1	1	2	3	6
2	1	0	1	2	1	2	0	1	2	0	0	5
1	0	0	0	1	1	0	0	0	0	1	0	0
N	36	36	36	38	38	36	36	36	36	38	38	37
mean	6.4	6.5	6.8	6.1	5.9	6.4	5.9	5.6	6.3	5.8	6.3	4.6
SD	1.9	1.7	1.6	2.0	1.9	1.7	1.8	1.7	1.6	1.9	1.7	1.8

(Continued)



**TABLE 12 - CONSUMER PANEL EVALUATION OF NUTRIENT ENHANCED FRUIT (Continued)**

**C. Color**

9	1	3	5	2	3	4	1	1	4	0	1	0
8	15	10	10	9	8	5	6	4	4	8	6	2
7	12	13	4	10	10	10	14	15	10	9	9	8
6	2	4	11	9	4	6	6	8	3	8	12	8
5	5	4	3	5	8	6	7	6	13	6	2	10
4	1	2	2	1	2	0	6	1	0	6	5	2
3	0	0	1	0	0	3	0	0	2	1	3	4
2	0	0	0	1	1	1	0	1	0	0	0	2
1	0	0	0	0	1	1	0	0	0	0	0	1
N	36	36	36	38	38	36	36	36	36	38	38	37
mean	7.1	6.9	6.8	6.5	6.4	6.2	6.5	6.4	6.3	6.1	6.1	5.2
SD	1.2	1.3	1.6	1.7	1.8	2.0	1.2	1.3	1.6	1.5	1.6	1.8

**D. Texture**

9	5	2	6	2	1	2	1	0	2	1	0	0
8	12	15	12	9	10	7	3	6	6	8	11	1
7	11	10	8	8	9	14	6	8	4	10	7	6
6	4	2	7	11	7	5	7	9	3	6	6	6
5	4	7	3	4	4	4	7	8	7	5	6	3
4	0	0	1	2	4	1	4	3	6	4	7	10
3	0	0	0	0	1	3	4	0	5	3	0	6
2	0	0	0	1	1	0	2	2	2	1	1	5
1	0	0	0	1	1	0	2	0	0	0	0	0
N	36	36	36	38	38	36	36	36	36	38	38	37
mean	7.3	7.1	7.2	6.4	6.2	6.5	5.2	5.9	5.3	6.1	6.1	4.6
SD	1.2	1.2	1.3	1.7	1.9	1.6	2.0	1.6	2.2	1.8	1.7	1.8

There was no difference due to treatment i.e. nutrient infusion or storage time. All the scores for the nutrient infused products were quite acceptable (a rating greater than 5.0).

**Technical Panel**

A fifteen member technical panel rated the products initially and after one month of storage at 120 ° F. The products stored in the barrier pouch were used. The results are presented in Table 13. The apples with minerals were not tested.

As with the consumer panel there was no difference due to treatments or storage time. All the ratings were quite acceptable (rating well above 5.0).

**TABLE 13 - TECHNICAL PANEL SCORES OF NUTRIENT ENHANCED FRUIT**

		<u>Sensory Characteristic</u>									
		<u>Overall</u>		<u>Odor</u>		<u>Flavor</u>		<u>Texture</u>		<u>Appearance</u>	
<u>Added</u>	<u>Acceptability</u>										
<u>Fruit</u>	<u>Nutrient</u>	<u>Storage Time, Months</u>									
		<u>0</u>	<u>1</u>	<u>0</u>	<u>1</u>	<u>0</u>	<u>1</u>	<u>0</u>	<u>1</u>	<u>0</u>	<u>1</u>
Cherries	Folic Acid										
	mean	7.1	6.6	6.6	6.6	6.9	6.6	6.9	7.0	6.9	6.8
	SD	0.7	0.9	0.9	0.9	1.2	1.4	1.0	1.0	0.9	1.2
Cherries	Mg, Zn										
	mean	7.2	6.5	7.0	6.7	6.8	6.5	7.2	6.7	7.0	6.5
	SD	0.9	1.0	0.8	1.0	1.1	1.2	0.8	1.0	0.9	1.2
Apples	Folic Acid										
	mean	6.7	5.9	6.5	6.3	6.9	6.0	6.7	6.4	6.8	6.0
	SD	1.0	0.9	1.4	1.2	0.9	0.9	1.2	1.1	1.1	1.0

#### Field Test

The results of a field test that was conducted at 29 Palms Marine Base are contained in Table 14. The products were served as part of a test for MRE components.

**TABLE 14 - FIELD TEST SCORES OF NUTRIENT ENHANCED FRUIT**

Fruit	Nutrient	Number of Panelists	Mean Score	Standard Deviation
Cherries	Folic Acid	14	7.4	1.5
Cherries	Mg, Zn	5	7.0	1.6
Apples	Folic Acid	29	7.3	2.4
Apples	Mg, Zn	17	7.4	1.9

All the products were highly rated. There was no significant difference for the added nutrients.

#### Nutrient Analyses

##### Folic Acid

Folic acid was analyzed initially and after one month of storage under contract using the standard AOAC method which uses bacterial growth. These data are contained in Table 15 and illustrated in Figure 7.

The values showed an apparent decrease with temperature after an initial increase. There was no significant difference due to the pouch materials. Since the AOAC method is a bacterial (*Streptococcus faecalis*) growth method the initial increase may be an artifact of the method. Subsequent analyses were done using the HPLC technique. However, it was discovered that the data was not accurate because of coeluting chemical species in cocromatographics, so it is not reported here.

Radet et al. (1999) studied alternate methods for folate analysis in cereal grain. She wrote that "microbiological assays in general are ... time-consuming, ...have poor precision and ... require experienced operators. HPLC methods are available with

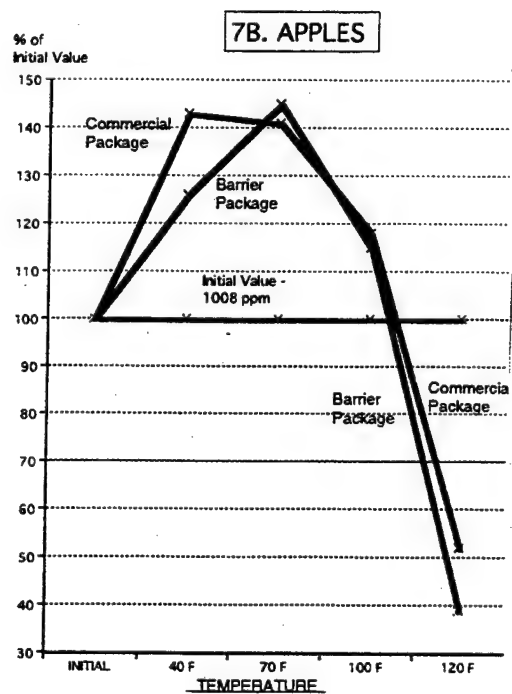
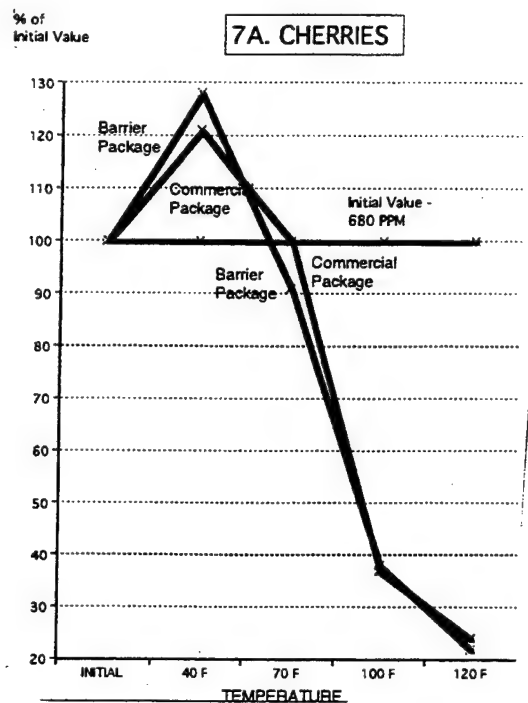


Fig. 7 - FOLIC ACID CONTENT OF NUTRIENT ENHANCED APPLES AND CHERRIES

good correlation with the microbiological assay. However "the accuracy of the HPLC analysis will be dependent upon the adequacy of the extraction and preparative...."

**TABLE 15 - FOLIC ACID CONTENT OF NUTRIENT ENHANCED FRUIT  
AFTER ONE MONTH STORAGE**

<u>Product</u>	<u>Package</u>	<u>Storage</u>	<u>Concentration</u>	
		<u>Temp. ° F</u>	<u>ppm</u>	
Apples	NA	NA	11	(Initial Value)
Apples	commercial	40	16	
Apples	commercial	70	14	
Apples	commercial	100	11	
Apples	commercial	120	5	
Apples	barrier	40	14	
Apples	barrier	70	15	
Apples	barrier	100	12	
Apples	barrier	120	3	
Cherries	NA	NA	9	(Initial Value)
Cherries	commercial	40	10	
Cherries	commercial	70	7	
Cherries	commercial	100	3	
Cherries	commercial	120	2	
Cherries	barrier	40	11	
Cherries	barrier	70	9	
Cherries	barrier	100	3	
Cherries	barrier	120	2	

There was a decrease in folic acid with increased storage temperature. There is no difference due to the pouch material indicating that the loss is due to the storage temperature. This indicates that a thermal rather than oxidative degradation mechanism predominates.

#### **Minerals**

These nutrients were analyzed initially and after one month of storage. Because there was essentially no change during storage, no further analyses were done.

The data is shown in Table 17. It is plotted in Figures 8 and 9. The data in these figures has also been plotted as a percent of the initial value. The mineral data shows no change with storage time, temperature or packaging material as expected. The data falls well within the range of sampling errors. The data is recalculated to 100% dryness/

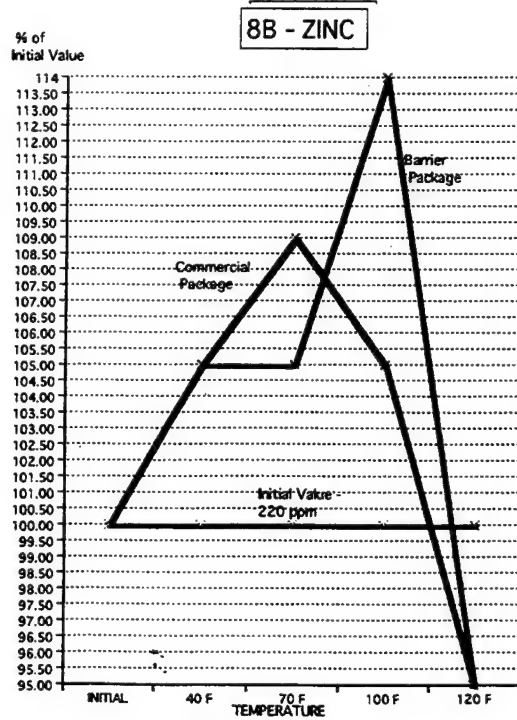
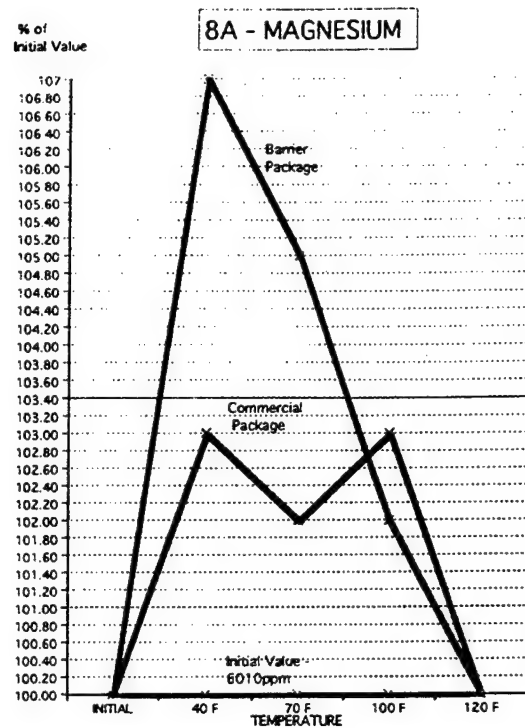


Fig. 8 - MINERAL CONTENT OF NUTRIENT ENHANCED APPLES

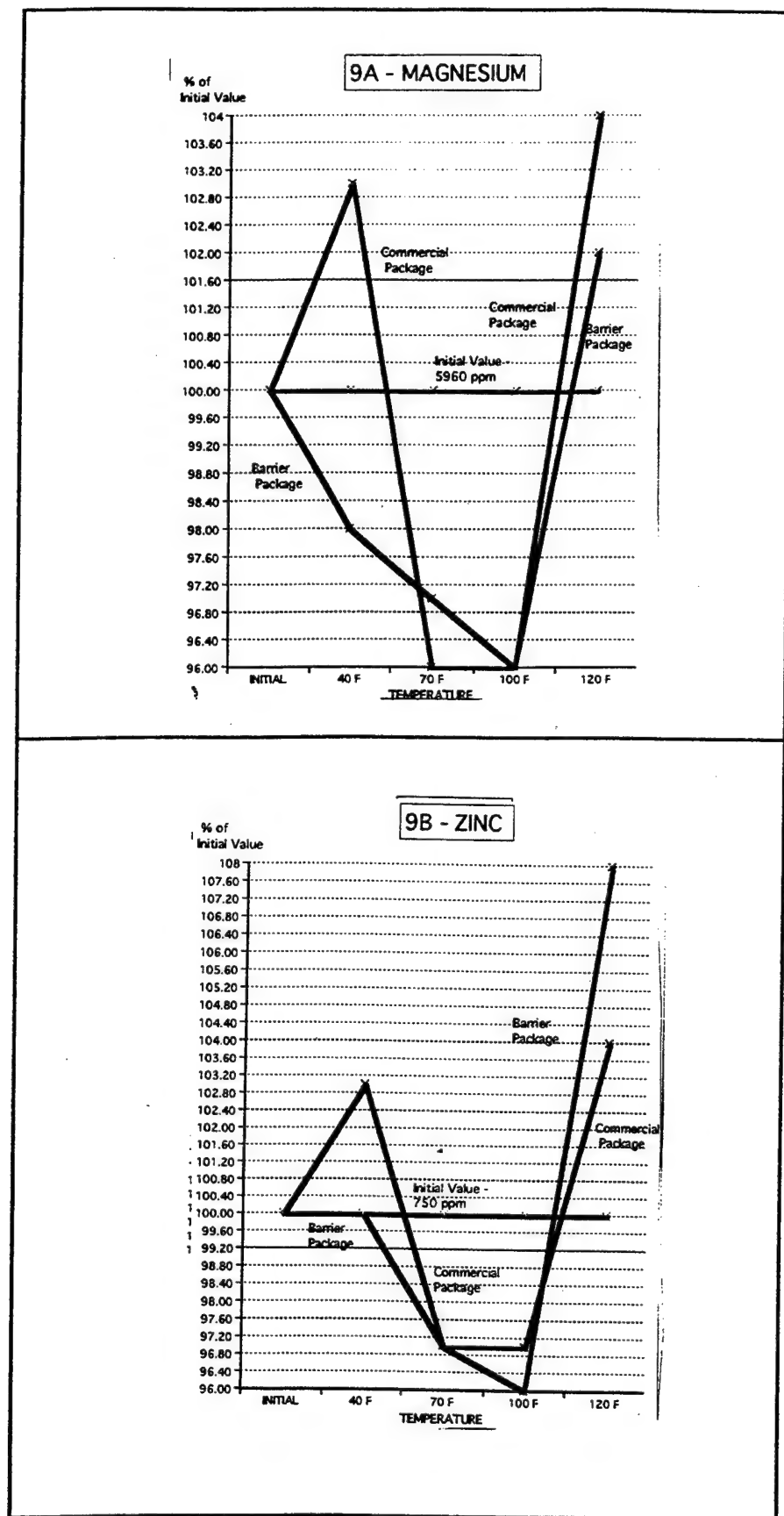


Fig. 9 - MINERAL CONTENT OF NUTRIENT ENHANCED CHERRIES

**TABLE 16 - MINERAL CONTENT OF NUTRIENT ENHANCED FRUIT**

<u>Storage</u>		<u>Storage</u>	<u>Packaging Material</u>			
<u>Product</u>	<u>Time, Months</u>	<u>Temp. °F.</u>	<u>Commercial</u>		<u>Barrier</u>	
			<u>Concentration, ppm</u>			
			<u>Mg</u>	<u>Zn</u>	<u>Mg</u>	<u>Zn</u>
Apples	0	NA	6010	220	6010	220
Apples	1	40	6220	230	6430	230
Apples	1	70	6160	230	6340	240
Apples	1	100	6200	250	6140	230
Apples	1	120	6030	210	6020	210
Cherries	0	NA	5960	750	5960	750
Cherries	1	40	6140	770	5820	750
Cherries	1	70	5750	730	5770	730
Cherries	1	100	5730	730	5670	720
Cherries	1	120	6190	780	6100	810*

### Physical Analyses

#### Water Activity

Table 17 contains the water activity data. They are plotted in Figures 10 and 11. With apples, there was a considerable drop in this value after 6 months. With cherries, the water activity held up well through twelve months except at 100 °F in the commercial pouch. With both the apples and cherries there was a decrease in the water activity with both increased storage temperature and time in the commercial pouch. This did not occur with the barrier pouch.

**TABLE 17 - WATER ACTIVITY OF NUTRIENT ENHANCED FRUIT**

<u>Data</u>		<u>Storage</u>	<u>Storage Time, Months</u>							
<u>Description</u>	<u>Package</u>	<u>Temp. °F</u>	<u>0</u>	<u>1</u>	<u>3</u>	<u>6</u>	<u>9</u>	<u>12</u>	<u>18</u>	<u>24</u>
<u>A. Apples with Added Minerals</u>										
smoothed	commercial	40	0.33	0.38	0.43	0.43	0.43	0.38	0.38	0.32
actual	commercial	40	0.33	0.38	0.43	0.44	0.34	0.45	0.32	0.38
smoothed	barrier	40	0.33	0.36	0.42	0.42	0.42	0.36	0.31	0.28
actual	barrier	40	0.33	0.36	0.43	0.42	0.31	0.43	0.28	0.36
smoothed	commercial	70	0.33	0.38	0.38	0.38	0.38	0.38	0.38	0.38
actual	commercial	70	0.33	0.39	0.38	0.46	0.31	0.48	0.38	0.39
smoothed	barrier	70	0.33	0.37	0.39	0.39	0.39	0.37	0.37	0.37
actual	barrier	70	0.37	0.33	0.39	0.44	0.34	0.51	0.37	0.43
smoothed	commercial	100	0.33	0.36	0.36	0.36	0.36	0.26	0.25	0.25
actual	commercial	100	0.33	0.38	0.36	0.42	0.26	0.43	0.25	0.30
smoothed	barrier	100	0.33	0.45	0.47	0.47	0.47	0.46	0.44	0.43
actual	barrier	100	0.33	0.45	0.47	0.50	0.44	0.51	0.46	0.43

(Continued)

**TABLE 27 - WATER ACTIVITY OF NUTRIENT ENHANCED FRUIT (Continued)**

**B. Apples with Added Vitamins**

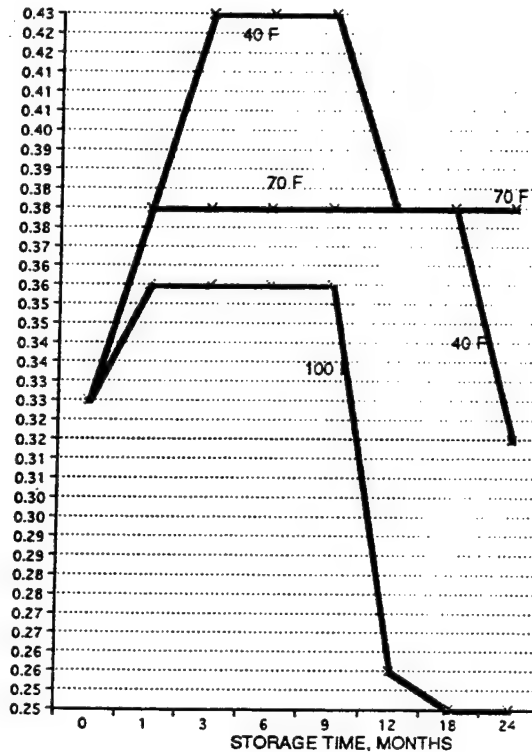
smoothed	commercial	40	0.37	0.40	0.43	0.43	0.43	0.40	0.40	0.28
actual	commercial	40	0.37	0.40	0.43	0.48	0.40	0.52	0.28	0.42
smoothed	barrier	40	0.37	0.39	0.39	0.39	0.39	0.38	0.37	0.32
actual	barrier	40	0.37	0.41	0.39	0.47	0.38	0.47	0.32	0.37
smoothed	commercial	70	0.37	0.39	0.42	0.42	0.42	0.36	0.35	0.34
actual	commercial	70	0.37	0.39	0.42	0.48	0.36	0.52	0.34	0.35
smoothed	barrier	70	0.37	0.39	0.41	0.41	0.41	0.37	0.37	0.37
actual	barrier	70	0.37	0.39	0.41	0.47	0.34	0.49	0.37	0.38
smoothed	commercial	100	0.37	0.37	0.37	0.36	0.36	0.29	0.29	0.26
actual	commercial	100	0.37	0.39	0.36	0.43	0.29	0.51	0.26	0.32
smoothed	barrier	100	0.37	0.40	0.40	0.40	0.50	0.50	0.50	0.37
actual	barrier	100	0.37	0.44	0.40	0.51	0.35	0.50	0.53	0.37
smoothed	commercial	40	0.44	0.44	0.45	0.45	0.45	0.45	0.44	0.43
actual	commercial	40	0.44	0.47	0.41	0.49	0.45	0.50	0.43	0.44
smoothed	barrier	40	0.44	0.47	0.47	0.47	0.47	0.45	0.42	0.40
actual	barrier	40	0.44	0.47	0.47	0.50	0.45	0.51	0.40	0.42
smoothed	commercial	70	0.44	0.45	0.45	0.45	0.44	0.44	0.41	0.36
actual	commercial	70	0.44	0.47	0.45	0.50	0.44	0.49	0.36	0.41
smoothed	barrier	70	0.44	0.47	0.47	0.47	0.47	0.45	0.43	0.42
actual	barrier	70	0.44	0.47	0.47	0.50	0.45	0.51	0.43	0.42
smoothed	commercial	100	0.44	0.44	0.44	0.41	0.41	0.32	0.30	0.25
actual	commercial	100	0.44	0.47	0.41	0.46	0.30	0.41	0.25	0.32
smoothed	barrier	100	0.44	0.47	0.47	0.47	0.47	0.47	0.47	0.36
actual	barrier	100	0.44	0.49	0.47	0.44	0.47	0.56	0.36	0.52

**D. Cherries with Added Vitamins**

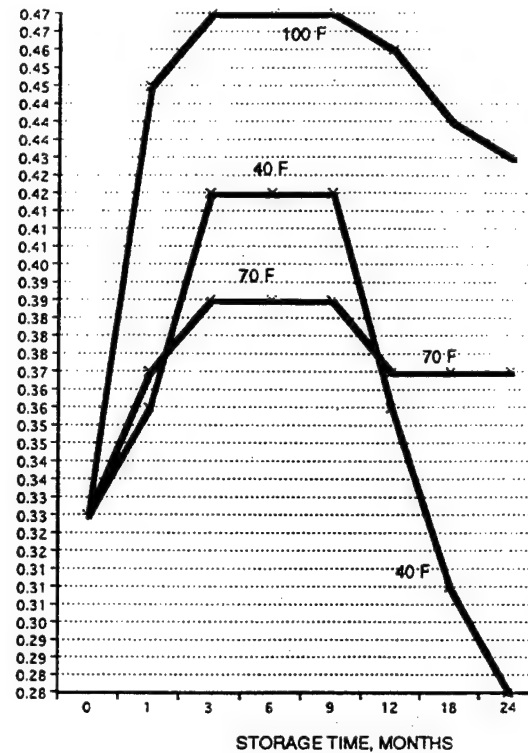
smoothed	commercial	40	0.42	0.46	0.46	0.49	0.50	0.50	0.44	0.41
actual	commercial	40	0.42	0.46	0.46	0.49	0.50	0.50	0.41	0.44
smoothed	barrier	40	0.42	0.45	0.46	0.46	0.46	0.44	0.44	0.37
actual	barrier	40	0.42	0.45	0.46	0.49	0.44	0.49	0.37	0.44
smoothed	commercial	70	0.42	0.44	0.44	0.44	0.44	0.43	0.39	0.39
actual	commercial	70	0.42	0.44	0.44	0.49	0.43	0.51	0.39	0.39
smoothed	barrier	70	0.42	0.45	0.45	0.45	0.45	0.44	0.40	0.39
actual	barrier	70	0.42	0.47	0.45	0.50	0.40	0.51	0.39	0.44
smoothed	commercial	100	0.42	0.42	0.42	0.41	0.41	0.33	0.33	0.27
actual	commercial	100	0.42	0.42	0.39	0.48	0.27	0.41	0.27	0.33
smoothed	barrier	100	0.42	0.46	0.47	0.47	0.49	0.49	0.49	0.31
actual	barrier	100	0.42	0.48	0.46	0.47	0.49	0.56	0.31	0.55



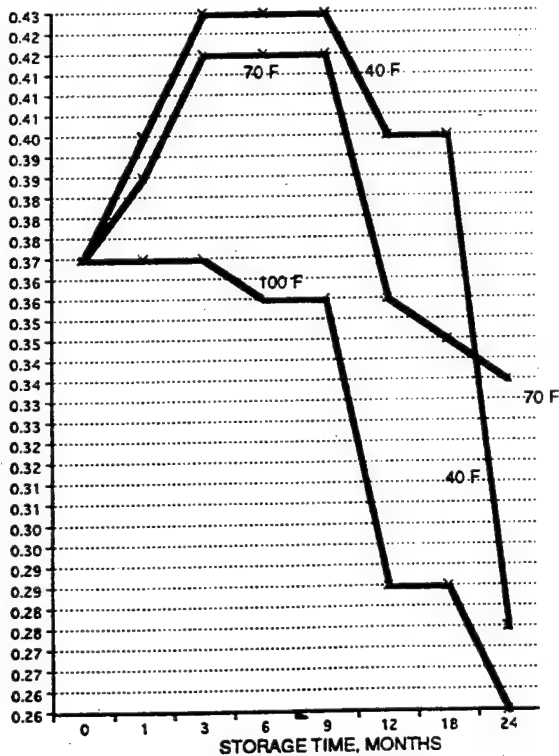
10A. MINERAL ENHANCED APPLES, COMMERCIAL PACKAGE



10B. MINERAL ENHANCED APPLES, BARRIER PACKAGE



10C. VITAMIN ENHANCED APPLES, COMMERCIAL PACKAGE



10D. VITAMIN ENHANCED APPLES, BARRIER PACKAGE

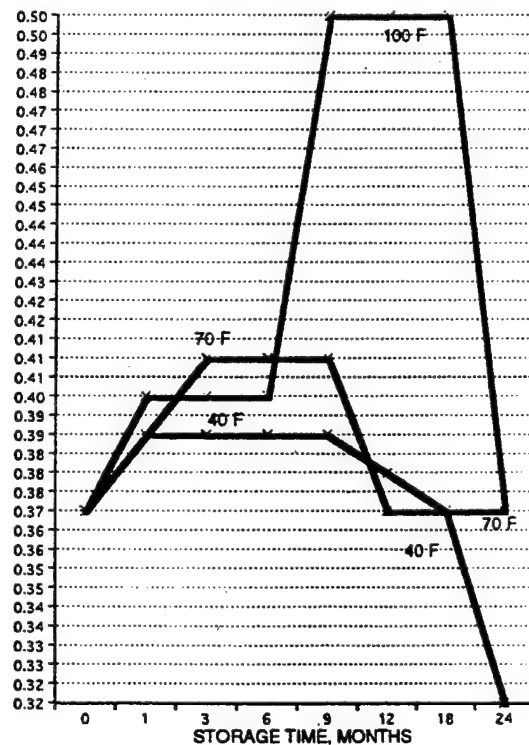
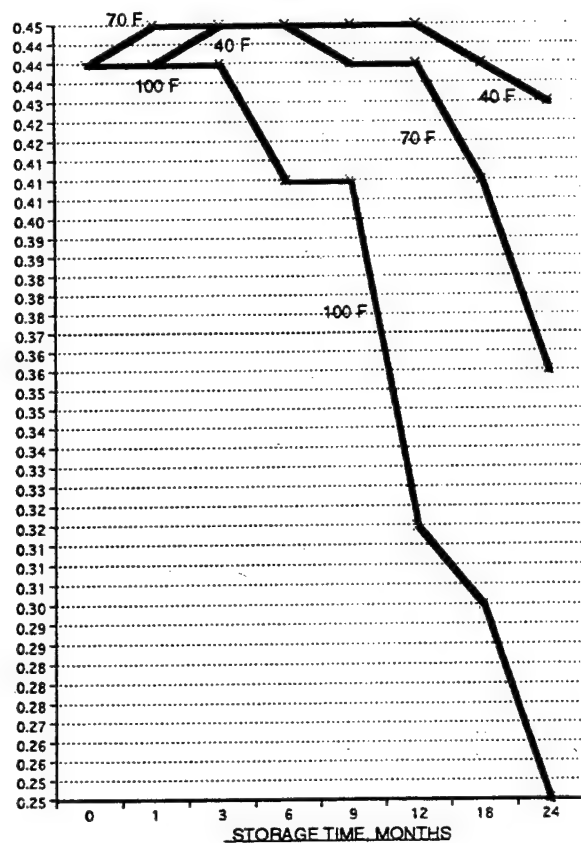
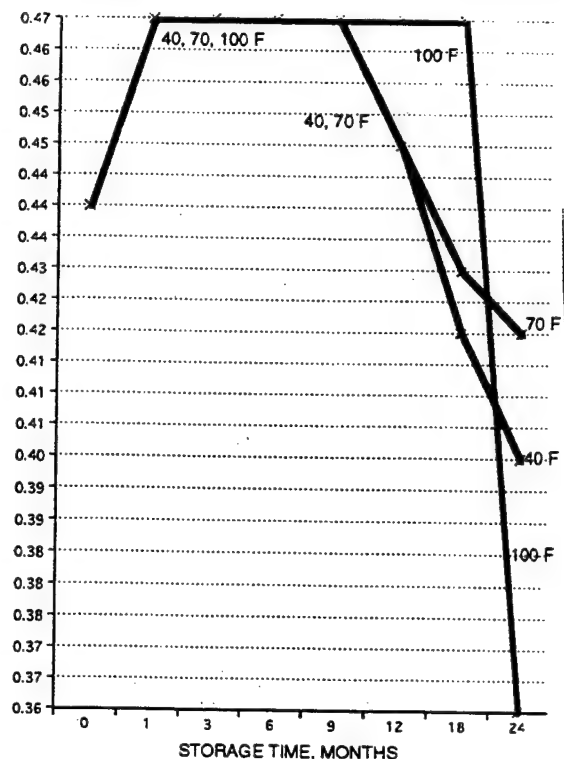


Fig. 10 - WATER ACTIVITY OF NUTRIENT ENHANCED APPLES

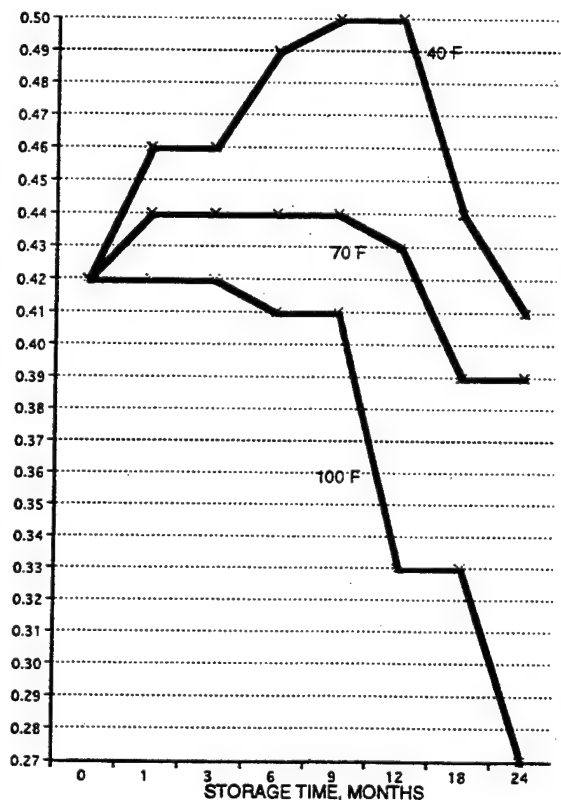
11A. MINERAL ENHANCED CHERRIES, COMMERCIAL PACKAGE



11B. MINERAL ENHANCED CHERRIES, BARRIER PACKAGE



11C. VITAMIN ENHANCED CHERRIES, COMMERCIAL PACKAGE



11D. VITAMIN ENHANCED CHERRIES, BARRIER PACKAGE

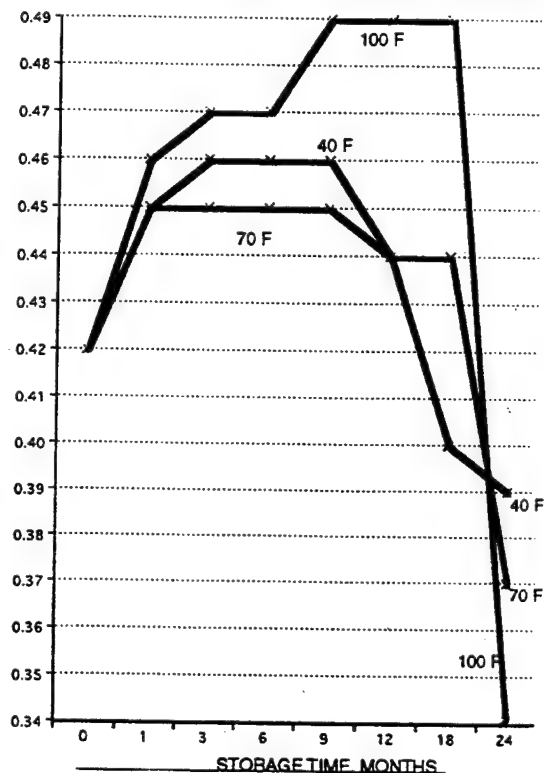


Fig. 11 - WATER ACTIVITY OF NUTRIENT ENHANCED CHERRIES

## Percent Moisture

Table 18 contains the percent moisture data. They are plotted in Figures 12 and 13.

There is a large decrease in moisture with increased storage time. The moisture of the apples drops almost to zero after 3 months of storage at 70 and 100 °F. This is less pronounced with the cherries, but still occurs. At 40 °F the moisture held up better than with the higher temperatures. The barrier material retains the moisture better than the commercial package.

**TABLE 18 - MOISTURE CONTENT OF NUTRIENT ENHANCED FRUIT**

<u>Data</u>		<u>Storage</u>	<u>Storage Time, Months</u>							
<u>Description</u>	<u>Package</u>	<u>Temp. °F</u>	<u>0</u>	<u>1</u>	<u>3</u>	<u>6</u>	<u>9</u>	<u>12</u>	<u>18</u>	<u>24</u>
<b>A. Apples with Added Minerals</b>										
smoothed	commercial	40	6.0	6.8	6.8	6.4	6.4	6.4	6.1	6.1
actual	commercial	40	6.0	6.8	8.9	4.2	6.4	4.4	6.4	6.1
smoothed	barrier	40	6.0	7.7	7.7	3.7	3.7	3.7	3.7	3.4
actual	barrier	40	6.0	8.2	7.7	3.7	3.7	4.7	3.4	5.0
smoothed	commercial	70	6.0	7.4	7.4	0.3	0.2	0.2	0.2	0.2
actual	commercial	70	6.0	7.4	7.9	0.3	0.2	0.2	0.2	2.9
smoothed	barrier	70	6.0	6.8	6.8	4.6	4.6	4.1	4.1	4.1
actual	barrier	70	6.0	7.1	5.2	0.4	0.5	4.6	4.1	4.9
smoothed	commercial	100	6.0	6.0	0.3	0.2	0.2	0.2	0.2	0.1
actual	commercial	100	6.0	6.0	0.3	0.2	0.1	0.2	0.2	0.1
smoothed	barrier	100	6.0	6.0	5.2	4.6	4.6	4.6	4.6	0.5
actual	barrier	100	6.0	7.1	5.2	0.4	0.5	4.6	5.3	0.5
<b>B. Apples with Added Vitamins</b>										
smoothed	commercial	40	7.0	7.0	7.0	7.0	7.7	7.7	7.1	7.1
actual	commercial	40	7.0	8.6	7.0	0.3	7.7	8.2	0.4	7.1
smoothed	barrier	40	7.0	7.2	7.2	6.1	6.1	6.9	6.9	5.4
actual	barrier	40	7.0	10.1	7.2	5.0	6.1	6.9	7.0	5.4
smoothed	commercial	70	7.0	7.0	6.9	0.2	0.2	0.2	0.2	0.1
actual	commercial	70	7.0	6.9	8.2	0.2	0.2	0.3	0.2	0.1
smoothed	barrier	70	7.0	8.5	8.5	5.0	2.8	0.1	0.1	0.1
actual	barrier	70	7.0	9.4	8.5	5.0	0.1	0.1	2.8	0.1
smoothed	commercial	100	7.0	5.0	0.3	0.2	0.2	0.2	0.1	0.1
actual	commercial	100	7.0	5.0	0.3	0.2	0.1	0.2	0.1	0.1
smoothed	barrier	100	7.0	7.6	7.6	0.3	0.3	0.2	0.1	0.1
actual	barrier	100	7.0	7.6	8.0	0.3	0.3	0.2	0.1	0.1

(Continued)

**TABLE 18 - MOISTURE CONTENT OF NUTRIENT ENHANCED FRUIT (Continued)**

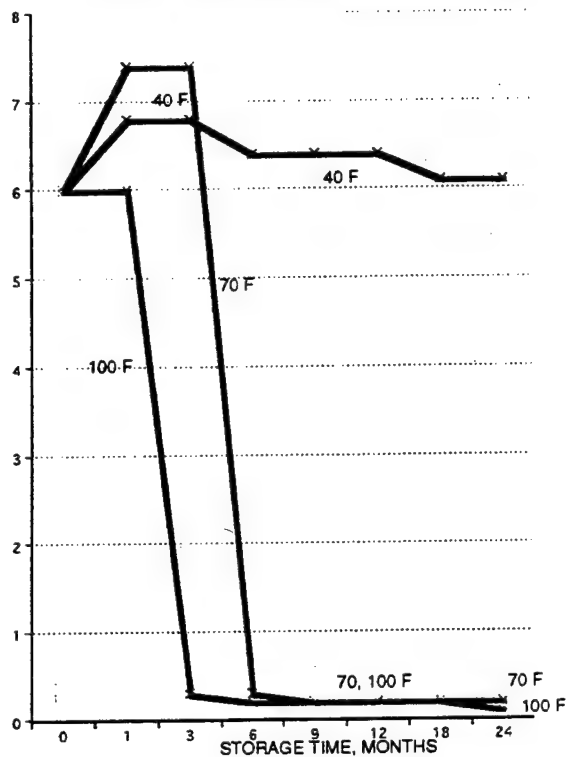
**C. Cherries with Added Minerals**

smoothed	commercial	40	21.8	25.1	25.1	18.0	18.0	18.6	18.6	18.1
actual	commercial	40	21.8	25.1	29.7	15.7	18.0	19.0	18.6	18.1
smoothed	barrier	40	21.8	22.7	22.7	17.5	17.5	18.6	18.6	16.6
actual	barrier	40	21.8	22.7	26.5	13.7	17.5	18.6	19.6	16.6
smoothed	commercial	70	21.8	21.8	21.8	20.9	18.0	18.0	16.5	11.8
actual	commercial	70	21.8	21.8	23.1	10.7	20.9	18.0	16.5	11.8
smoothed	barrier	70	21.8	23.8	23.8	21.9	21.9	21.9	18.9	15.2
actual	barrier	70	21.8	23.8	27.8	16.3	21.9	15.2	23.4	18.9
smoothed	commercial	100	21.8	23.3	23.3	0.3	0.1	0.1	0.1	0.1
actual	commercial	100	21.8	23.8	23.3	0.3	0.1	0.1	0.2	0.1
smoothed	barrier	100	21.8	21.8	20.6	17.4	17.4	17.4	17.4	5.3
actual	barrier	100	21.8	20.6	23.5	15.4	17.4	19.9	5.3	21.7

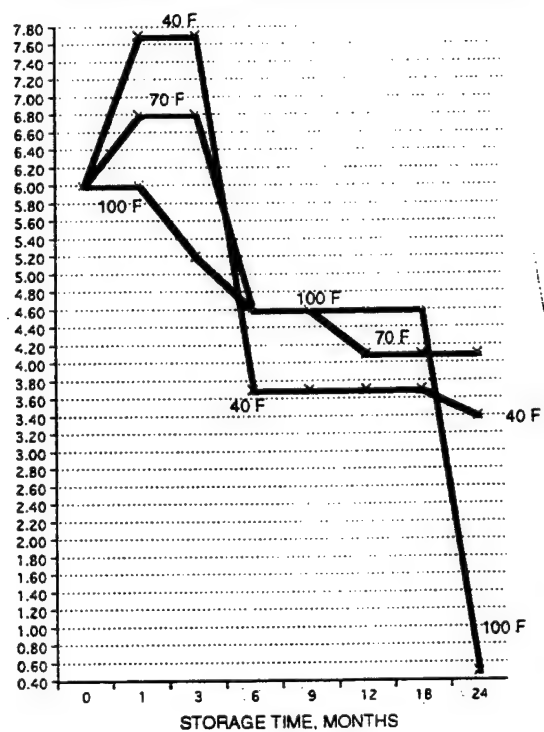
**D. Cherries with Added Vitamins**

smoothed	commercial	40	22.0	21.4	21.1	15.6	15.0	15.0	15.0	14.1
actual	commercial	40	22.0	21.1	21.4	5.3	15.6	15.0	14.1	21.5
smoothed	barrier	40	22.0	21.2	20.9	14.9	14.9	14.9	14.2	13.6
actual	barrier	40	22.0	20.9	21.2	8.4	14.9	16.1	14.2	13.6
smoothed	commercial	70	22.0	19.5	18.7	18.7	15.8	14.4	9.3	8.8
actual	commercial	70	22.0	19.5	18.0	18.7	14.4	15.8	8.8	9.3
smoothed	barrier	70	22.0	22.0	19.5	15.9	15.0	12.9	11.3	10.9
actual	barrier	70	22.0	24.1	19.5	15.0	15.9	12.9	11.3	10.9
smoothed	commercial	100	22.0	19.3	15.3	0.4	0.2	0.2	0.1	0.1
actual	commercial	100	22.0	15.3	19.3	0.4	0.2	0.2	0.1	0.1
smoothed	barrier	100	22.0	18.9	18.0	17.6	15.6	15.4	15.4	15.4
actual	barrier	100	22.0	18.9	17.6	18.0	12.1	15.6	0.1	15.4

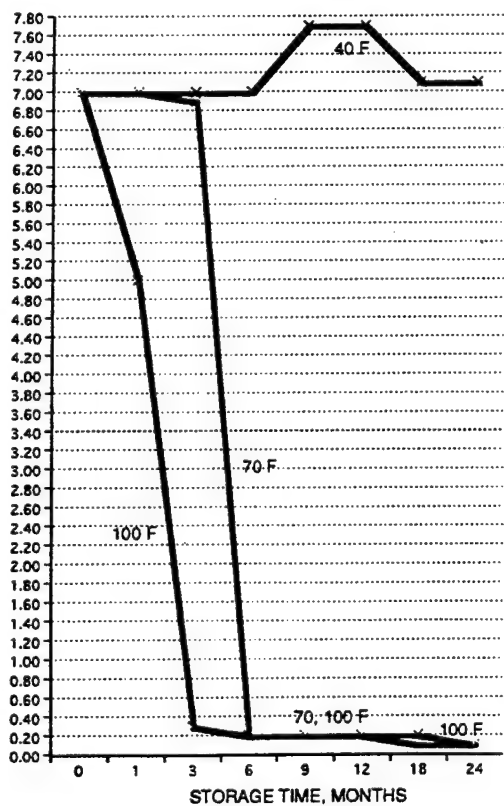
12A. MINERAL ENHANCED APPLES, COMMERCIAL PACKAGE



12B. MINERAL ENHANCED APPLES, BARRIER PACKAGE



12C. VITAMIN ENHANCED APPLES, COMMERCIAL PACKAGE



12D. VITAMIN ENHANCED APPLES, BARRIER PACKAGE

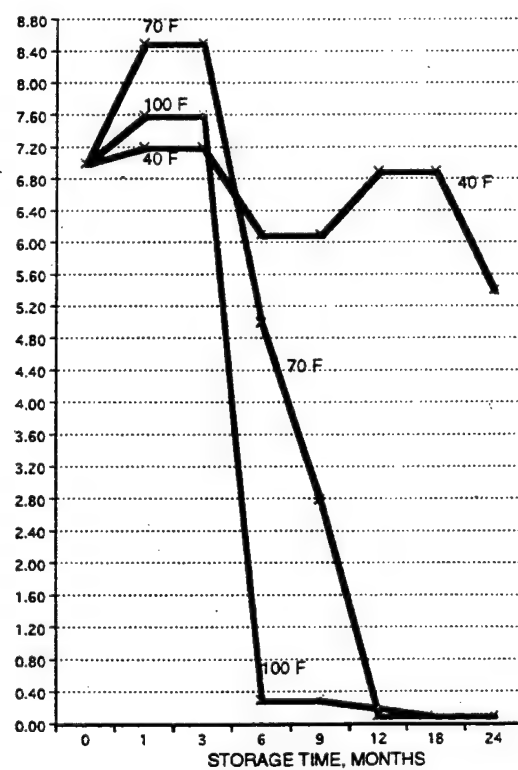
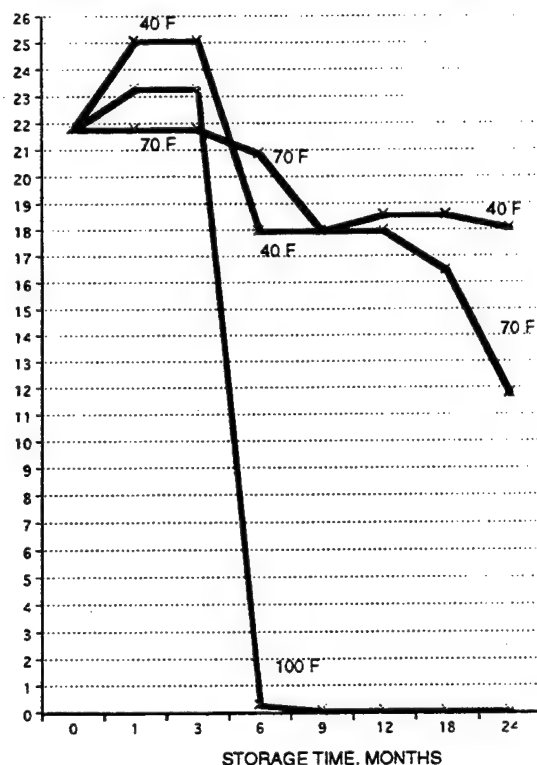
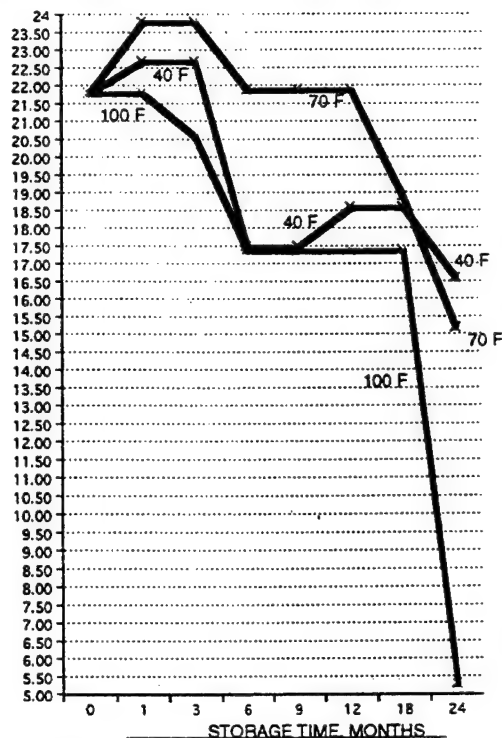


Fig. 12 - MOISTURE CONTENT OF NUTRIENT ENHANCED APPLES

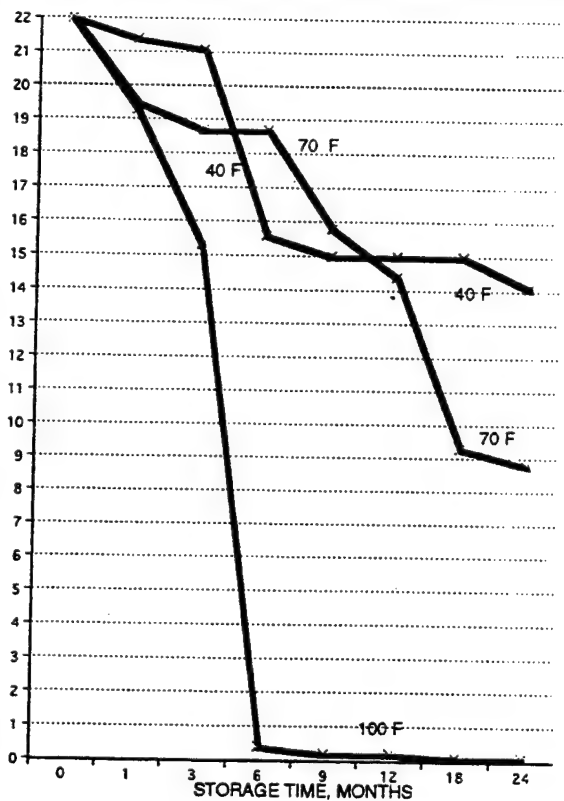
13A. MINERAL ENHANCED CHERRIES, COMMERCIAL PACKAGE



13B. MINERAL ENHANCED CHERRIES, BARRIER PACKAGE



13C. VITAMIN ENHANCED CHERRIES, COMMERCIAL PACKAGE



13D. VITAMIN ENHANCED CHERRIES, BARRIER PACKAGE

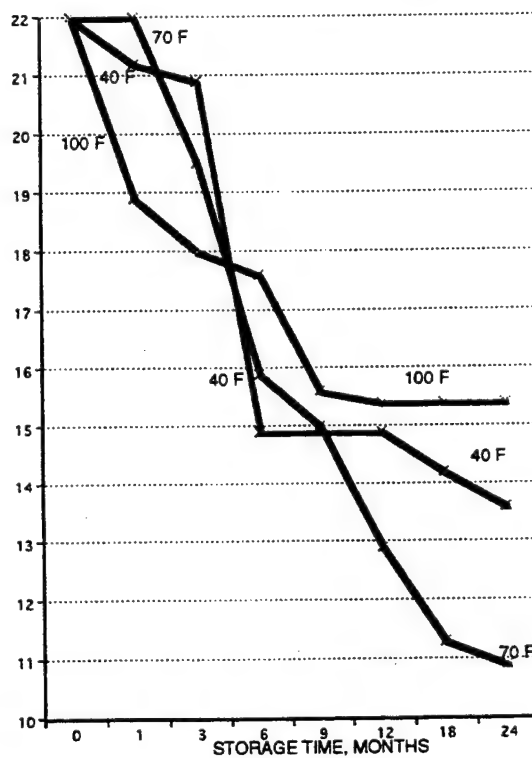


Fig. 13 - MOISTURE CONTENT OF NUTRIENT ENHANCED CHERRIES

## Reflectance Color

### L Values

Table 19 contains the L value data. They are plotted in Figures 14 and 15 .

There is a distinct decrease in the values with increased storage time for both the apples and the cherried. The apples also showed a decrease in value at the 100 °F storage temperature with both pouches. This indicates a darkening of the fruit. The vitamin fortified apples have darkened only slightly at the lower temperatures. The mineral fortified apples also held up well at the lower temperatures except for those stored at 70 °F in the commercial pouch.

**TABLE 19-REFLECTANCE L VALUES FOR NUTRIENT ENHANCED FRUIT**

<u>Data</u>		<u>Storage</u>	<u>Storage Time, Months</u>							
<u>Description</u>	<u>Package</u>	<u>Temp. °F</u>	<u>0</u>	<u>1</u>	<u>3</u>	<u>6</u>	<u>9</u>	<u>12</u>	<u>18</u>	<u>24</u>
<b><u>A. Apples with Added Minerals</u></b>										
smoothed	commercial	40	41.9	44.8	45.5	45.5	45.5	45.5	45.0	44.7
actual	commercial	40	41.9	49.8	44.8	45.5	44.7	45.8	46.2	45.0
smoothed	barrier	40	41.9	45.9	46.4	46.4	46.4	45.9	45.9	45.8
actual	barrier	40	41.9	45.9	46.9	46.4	47.2	45.8	45.9	47.8
smoothed	commercial	70	41.9	47.6	47.6	45.3	45.0	43.2	43.2	40.8
actual	commercial	70	41.9	51.1	47.6	45.3	41.3	45.0	43.2	40.8
smoothed	barrier	70	41.9	45.3	45.3	45.3	46.3	46.3	44.1	42.2
actual	barrier	70	41.9	48.3	45.3	44.8	46.3	47.0	44.1	42.2
smoothed	commercial	100	41.9	47.5	47.5	45.5	40.3	37.1	36.8	29.0
actual	commercial	100	41.9	47.9	47.5	45.5	40.3	37.1	36.8	29.0
smoothed	barrier	100	41.9	41.9	37.4	37.4	34.0	31.3	26.6	22.7
actual	barrier	100	41.9	52.2	20.9	37.4	34.0	31.3	26.6	22.7
<b><u>A. Apples with Added Vitamins</u></b>										
smoothed	commercial	40	42.8	42.8	42.8	42.0	41.8	41.5	40.6	39.0
actual	commercial	40	42.8	43.7	42.0	43.0	40.6	41.8	39.0	41.5
smoothed	barrier-	40	42.8	42.9	42.9	42.9	42.6	42.6	42.0	38.8
actual	barrier	40	42.8	48.6	42.9	41.3	43.5	42.6	38.8	42.0
smoothed	commercial	70	42.8	42.8	41.9	41.5	41.1	36.6	35.4	34.5
actual	commercial	70	42.8	46.5	41.9	41.5	41.1	36.6	34.5	35.4
smoothed	barrier	70	42.8	43.0	43.0	40.8	40.7	36.8	34.4	34.2
actual	barrier	70	42.8	49.8	43.0	40.7	40.8	36.8	34.4	34.2
smoothed	commercial	100	42.8	42.5	35.9	33.2	30.8	30.0	30.0	25.8
actual	commercial	100	42.8	42.5	35.9	33.2	30.8	30.0	25.8	36.9
smoothed	barrier	100	42.8	42.8	34.8	30.9	26.4	23.1	23.1	16.8
actual	barrier	100	42.8	47.7	34.8	30.9	26.4	23.1	16.8	25.9

(Continued)

**TABLE 19 -REFLECTANCE L VALUES FOR NUTRIENT ENHANCED FRUIT (Continued)**

**C. Cherries with Added Minerals**

smoothed	commercial	40	17.8	20.4	20.4	19.0	19.0	19.0	18.2	18.2
actual	commercial	40	17.8	25.7	20.4	17.4	19.0	16.7	19.8	18.2
smoothed	barrier	40	17.8	20.9	20.9	18.9	18.9	19.8	19.8	19.8
actual	barrier	40	17.8	26.3	20.9	18.9	18.1	19.8	20.7	17.6
smoothed	commercial	70	17.8	21.0	21.0	19.8	19.3	19.3	18.7	17.4
actual	commercial	70	17.8	27.7	21.0	19.8	19.3	18.7	19.3	17.4
smoothed	barrier	70	17.8	19.6	20.1	20.1	20.1	19.3	19.3	17.3
actual	barrier	70	17.8	25.7	19.6	20.7	18.7	20.1	19.3	17.3
smoothed	commercial	100	17.8	22.7	22.7	18.4	17.5	17.5	17.5	16.4
actual	commercial	100	17.8	26.7	22.7	18.4	17.4	17.5	18.9	16.4
smoothed	barrier	100	17.8	22.3	22.3	19.2	19.2	18.9	18.9	17.4
actual	barrier	100	17.8	27.4	22.3	19.2	18.4	19.2	18.9	17.4

**D. Cherries with Added Vitamins**

smoothed	commercial	40	17.5	21.0	21.0	18.2	17.7	17.7	16.6	16.6
actual	commercial	40	17.5	26.2	21.0	17.4	18.2	13.3	17.7	16.6
smoothed	barrier	40	17.5	20.5	20.5	17.1	17.1	18.9	18.9	18.5
actual	barrier	40	17.5	25.8	20.5	17.1	16.9	18.9	19.1	18.5
smoothed	commercial	70	17.5	20.4	20.4	18.9	18.9	18.9	17.0	17.0
actual	commercial	70	17.5	25.7	20.4	18.8	18.9	16.5	20.1	17.0
smoothed	barrier	70	17.5	19.6	19.6	18.8	18.7	18.7	18.7	17.6
actual	barrier	70	17.5	25.7	19.6	18.8	17.4	18.7	19.4	17.6
smoothed	commercial	100	17.5	21.6	21.6	16.8	16.8	17.1	17.1	16.9
actual	commercial	100	17.5	28.7	21.6	16.8	14.3	17.1	19.4	16.9
smoothed	barrier	100	17.5	20.9	20.9	17.9	17.9	18.1	18.1	16.4
actual	barrier	100	17.5	27.0	20.9	17.9	16.2	18.3	18.1	16.4



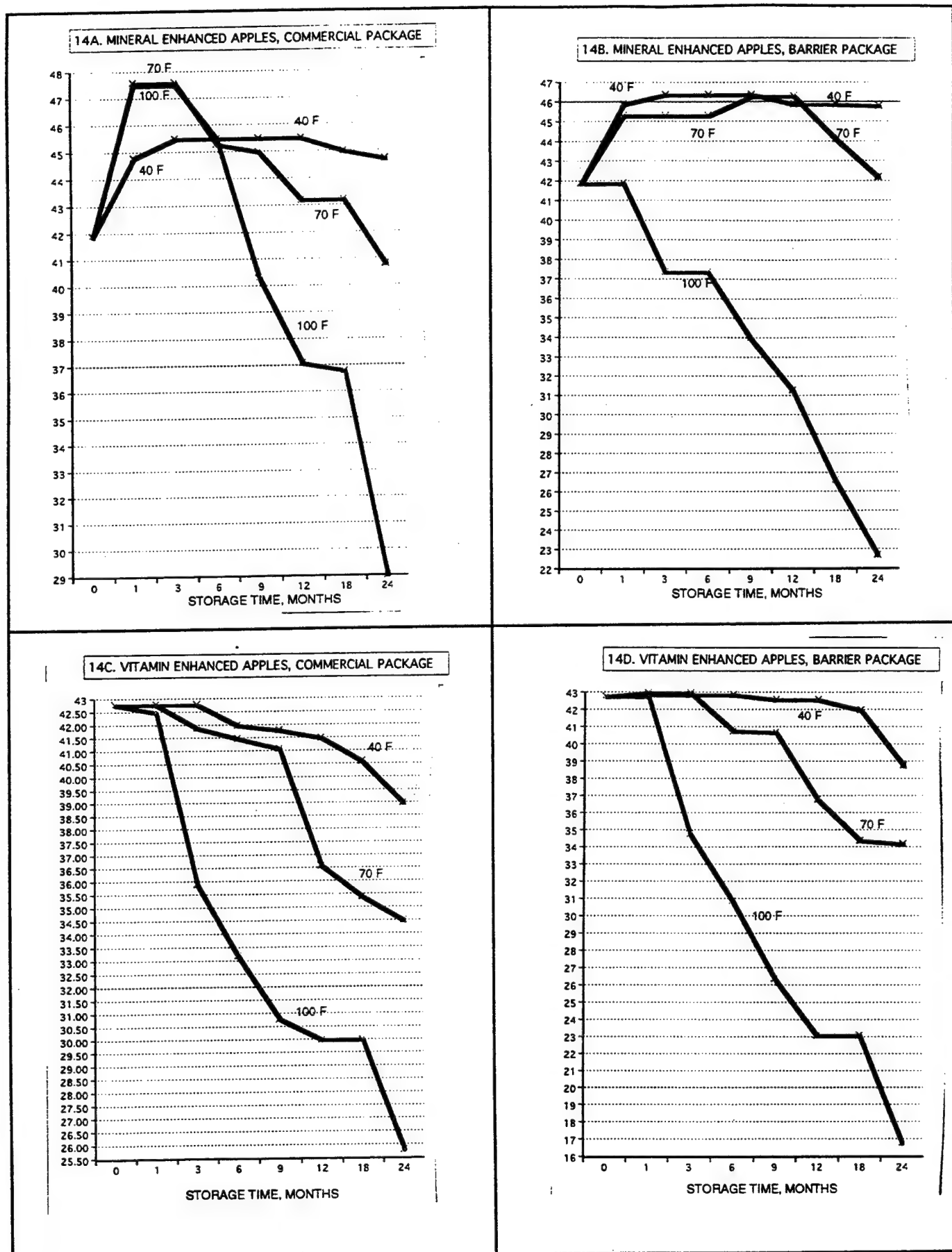
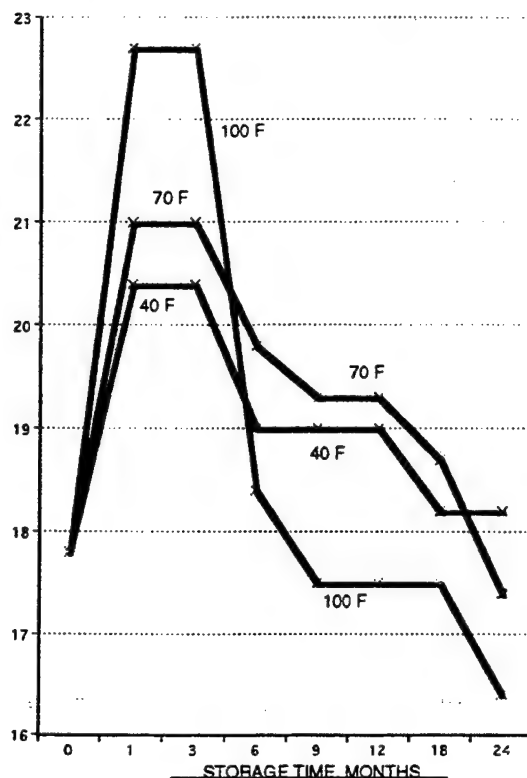
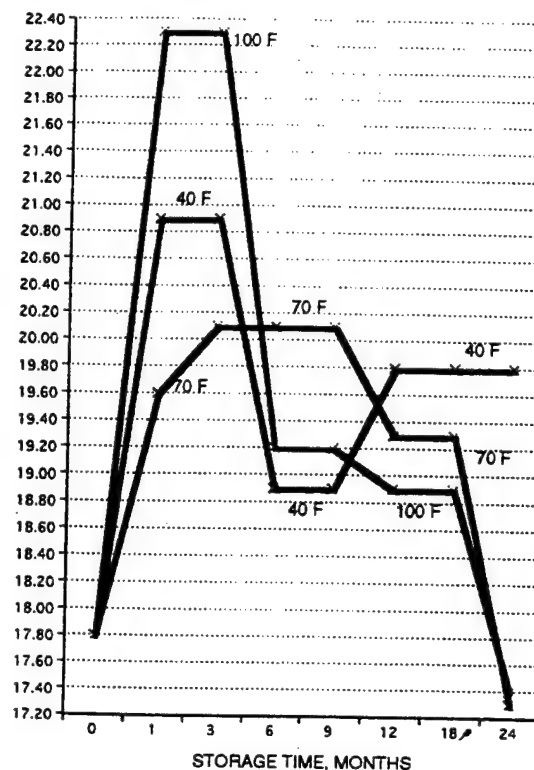


Fig. 14 - REFLECTANCE L VALUES OF NUTRIENT ENHANCED APPLES

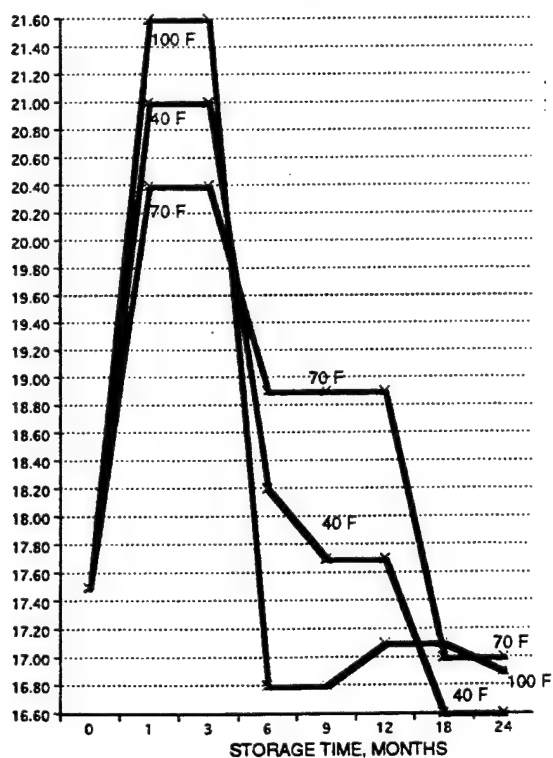
15A. MINERAL ENHANCED CHERRIES, COMMERCIAL PACKAGE



15B. MINERAL ENHANCED CHERRIES, BARRIER PACKAGE



15C. VITAMIN ENHANCED CHERRIES, COMMERCIAL PACKAGE



15D. VITAMIN ENHANCED CHERRIES, BARRIER PACKAGE

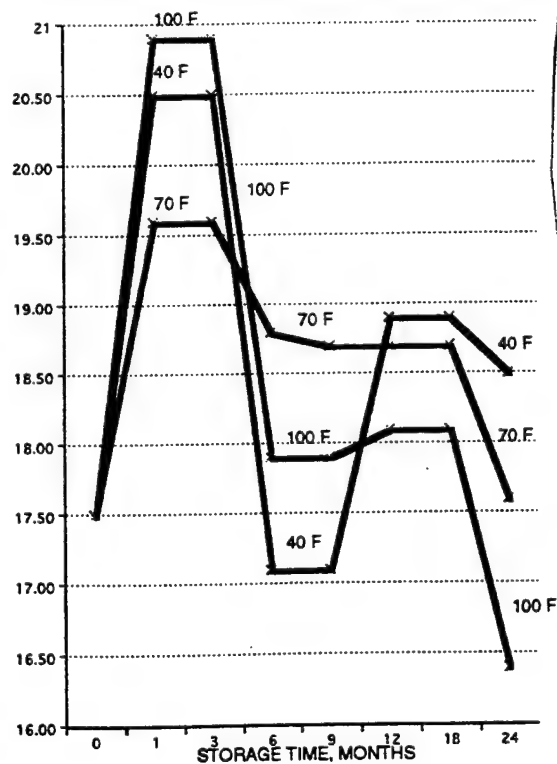


Fig. 15 - REFLECTANCE L VALUES OF NUTRIENT ENHANCED CHERRIES

**Reflectance Color  
a Values**

Table 20 contains the a value data. They are plotted in Figures 16 and 17.

The apple values at 40 and 70 °F storage slightly decreased with time indicating a reddening. At 100 °F storage the values increased indicating a loss of the red pigment. With the cherries there was an initial increase in red through 3 months of storage. After that the values tended to stabilize.

**TABLE 20 - REFLECTANCE a VALUES FOR NUTRIENT ENHANCED FRUIT**

<u>Data</u>		<u>Storage</u>	<u>Storage Time, Months</u>							
<u>Description</u>	<u>Package</u>	<u>Temp. °F</u>	<u>0</u>	<u>1</u>	<u>3</u>	<u>6</u>	<u>9</u>	<u>12</u>	<u>18</u>	<u>24</u>
<b>A. Apples with Added Minerals</b>										
smoothed	commercial	40	4.8	4.8	4.8	4.1	3.9	3.9	3.9	3.7
actual	commercial	40	4.8	5.5	4.1	4.8	3.9	3.7	4.3	4.2
smoothed	barrier	40	4.8	4.8	4.7	4.7	4.7	4.3	4.1	4.1
actual	barrier	40	4.8	4.8	3.8	4.7	4.8	4.0	4.3	4.1
smoothed	commercial	70	4.8	4.4	3.7	3.5	3.5	3.8	4.2	4.2
actual	commercial	70	4.8	4.4	3.7	3.5	3.4	3.8	4.2	4.8
smoothed	barrier	70	4.8	4.8	3.9	3.9	3.8	3.8	4.0	4.0
actual	barrier	70	4.8	5.0	3.9	3.9	3.8	3.0	4.0	4.3
smoothed	commercial	100	4.8	4.8	5.4	6.7	6.8	6.9	7.6	7.8
actual	commercial	100	4.8	4.5	5.4	6.8	6.7	6.9	7.6	7.8
smoothed	barrier	100	4.8	5.3	6.1	7.1	7.1	6.7	6.7	6.2
actual	barrier	100	4.8	5.3	6.1	7.1	7.6	6.7	7.4	6.2
<b>B. Apples with Added Vitamins</b>										
smoothed	commercial	40	6.5	5.5	5.2	5.2	5.2	5.2	5.2	5.2
actual	commercial	40	6.5	5.5	5.1	5.2	5.6	4.9	5.2	5.4
smoothed	barrier	40	6.5	5.9	5.7	5.3	5.3	5.3	5.7	5.8
actual	barrier	40	6.5	5.9	5.1	5.7	5.3	5.0	5.7	5.8
smoothed	commercial	70	6.5	6.5	6.2	6.2	6.4	6.5	7.1	7.1
actual	commercial	70	6.5	6.7	6.0	6.2	6.4	6.5	7.3	7.1
smoothed	barrier	70	6.5	6.0	5.7	5.7	5.7	6.2	6.9	6.9
actual	barrier	70	6.5	6.0	4.9	5.7	6.2	5.4	7.1	6.9
smoothed	commercial	100	6.5	7.5	7.9	8.6	8.6	8.6	8.5	7.9
actual	commercial	100	6.5	7.9	7.5	8.9	8.6	8.5	9.9	7.9
smoothed	barrier	100	6.5	6.5	7.5	7.5	6.7	6.0	5.6	4.4
actual	barrier	100	6.5	6.3	7.5	8.1	6.7	6.0	5.6	4.4

(Continued)

**TABLE 20 - REFLECTANCE a VALUES FOR NUTRIENT ENHANCED FRUIT (Continued)**

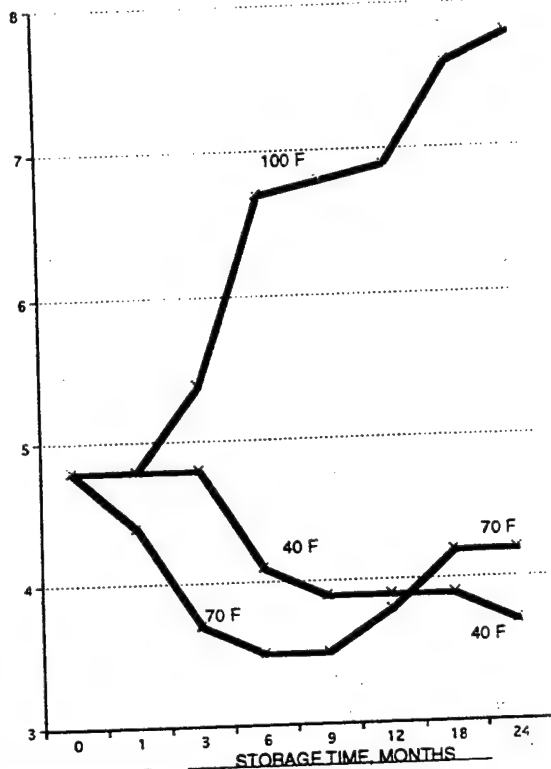
**C. Cherries with Added Minerals**

smoothed	commercial	40	3.8	2.4	2.3	2.3	2.3	2.3	2.3	1.7
actual	commercial	40	3.8	2.4	1.7	2.3	2.6	2.3	1.7	2.4
smoothed	barrier	40	3.8	2.5	2.0	2.0	2.0	2.0	2.1	2.1
actual	barrier	40	3.8	2.5	1.7	2.0	2.3	1.7	2.2	2.1
smoothed	commercial	70	3.8	2.4	1.5	1.5	1.3	1.0	0.7	0.7
actual	commercial	70	3.8	2.4	1.5	1.5	1.3	1.0	0.7	0.7
smoothed	barrier	70	3.8	2.7	1.5	1.4	1.3	1.0	0.9	0.8
actual	barrier	70	3.8	2.7	1.4	1.5	1.3	1.0	0.9	0.8
smoothed	commercial	100	3.8	0.9	0.2	0.1	0.0	-0.1	-0.1	0.0
actual	commercial	100	3.8	0.9	0.2	0.0	0.1	-0.2	-0.1	0.0
smoothed	barrier	100	3.8	1.1	0.2	0.1	-0.1	-0.1	-0.1	-0.1
actual	barrier	100	3.8	1.1	0.2	0.1	-0.1	-0.2	-0.1	-0.1

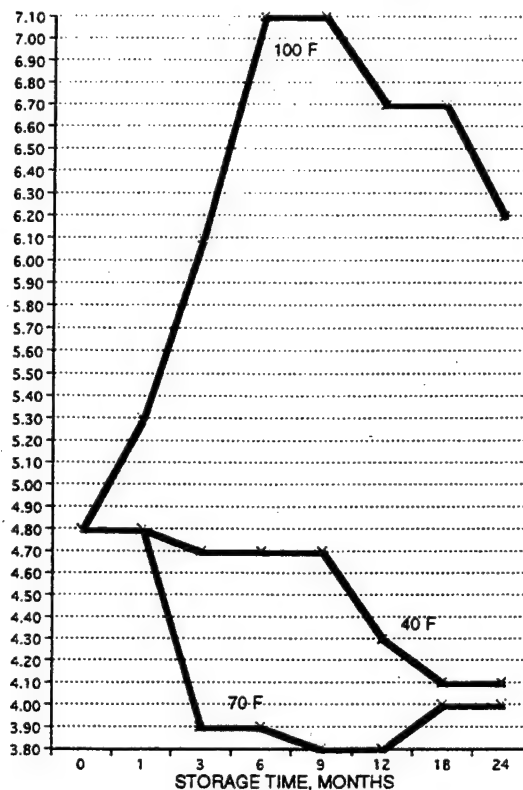
**D. Cherries with Added Vitamins**

smoothed	commercial	40	3.1	2.2	1.9	1.9	2.3	2.3	1.9	1.6
actual	commercial	40	3.1	2.2	1.7	1.9	2.3	2.4	1.6	1.9
smoothed	barrier	40	3.1	2.1	1.9	1.7	1.7	1.6	1.6	1.4
actual	barrier	40	3.1	2.1	1.7	1.9	1.7	1.6	1.4	2.0
smoothed	commercial	70	3.1	2.9	1.3	1.3	1.3	1.1	0.8	0.4
actual	commercial	70	3.1	2.9	1.2	1.3	1.4	1.1	0.8	0.4
smoothed	barrier	70	3.1	2.4	1.7	1.4	1.3	1.0	0.7	0.3
actual	barrier	70	3.1	2.4	1.7	1.3	1.4	1.0	0.7	0.3
smoothed	commercial	100	3.1	1.1	0.1	0.1	0.1	-0.1	-0.2	-0.2
actual	commercial	100	3.1	1.1	0.1	0.1	0.1	-0.1	-0.2	-0.2
smoothed	barrier	100	3.1	1.3	0.1	0.1	0.0	-0.2	-0.2	-0.2
actual	barrier	100	3.1	1.3	0.1	0.1	0.0	-0.2	-0.2	-0.1

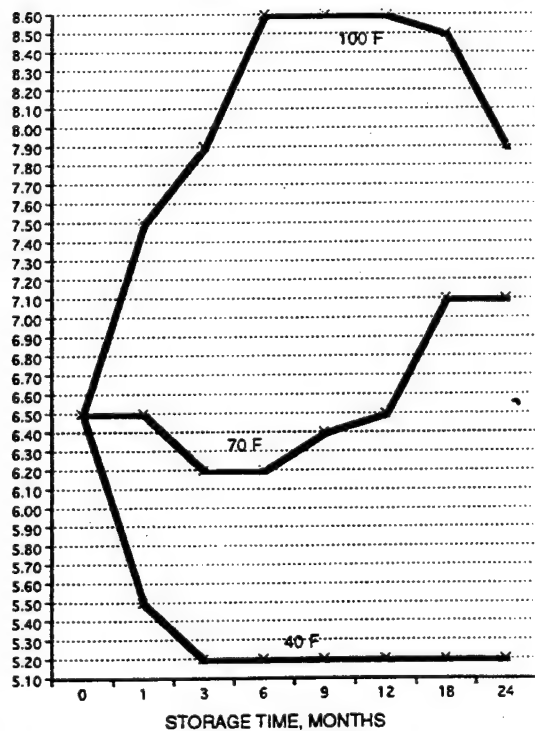
16A. MINERAL ENHANCED APPLES, COMMERCIAL PACKAGE



16B. MINERAL ENHANCED APPLES, BARRIER PACKAGE



16C. VITAMIN ENHANCED APPLES, COMMERCIAL PACKAGE



16D. VITAMIN ENHANCED APPLES, BARRIER PACKAGE

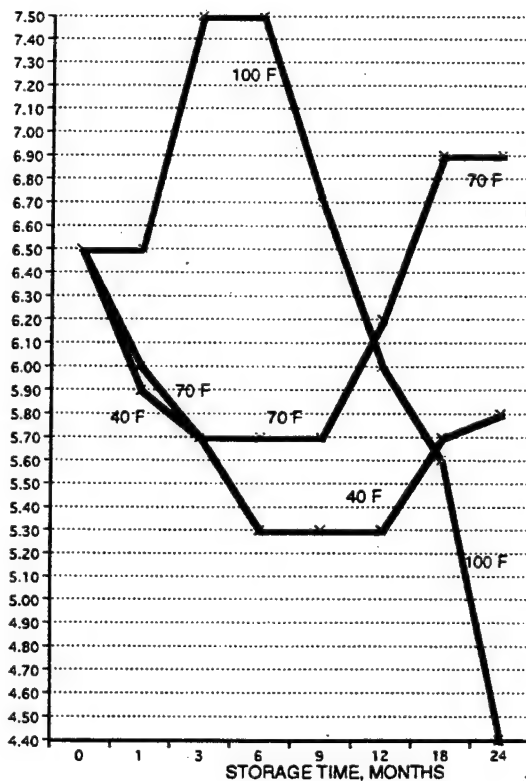
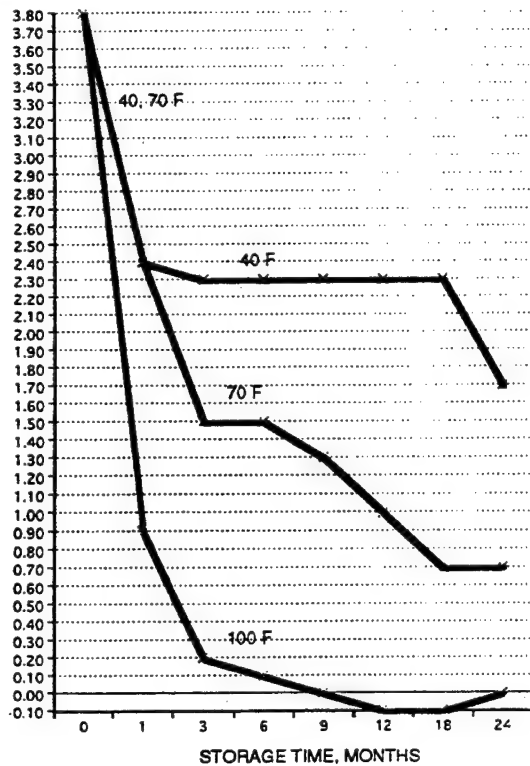
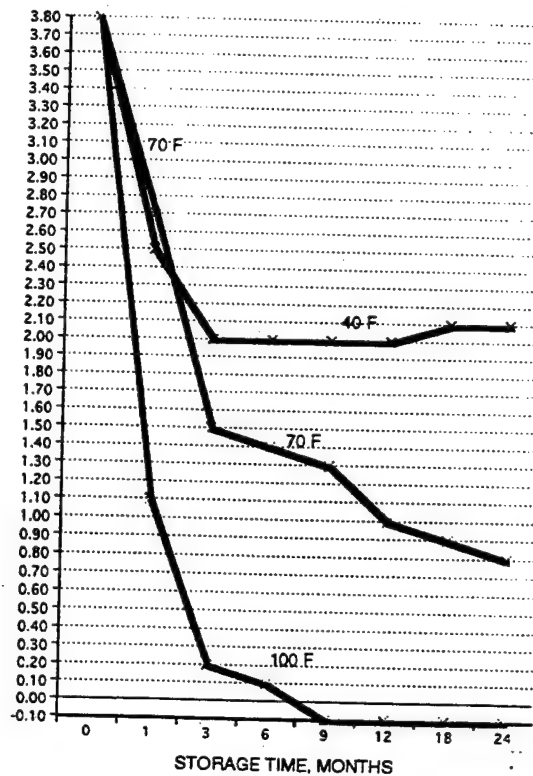


Fig. 16 - REFLECTANCE a VALUES OF NUTRIENT ENHANCED APPLES

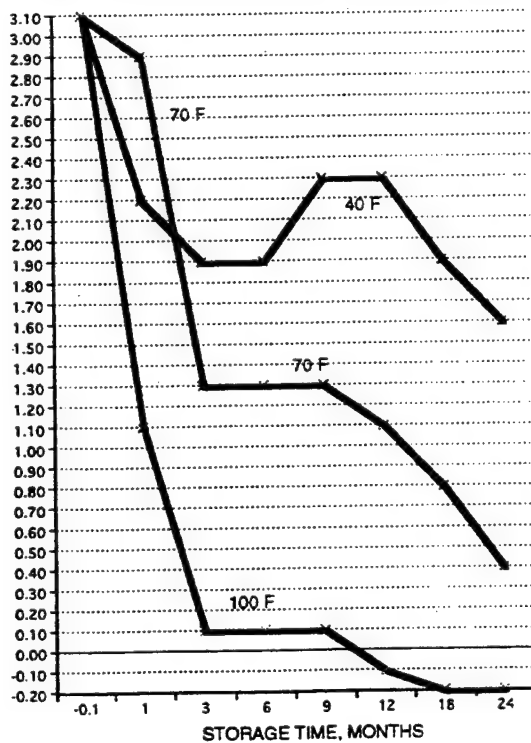
17A. MINERAL ENHANCED CHERRIES, COMMERCIAL PACKAGE



17B. MINERAL ENHANCED CHERRIES, BARRIER PACKAGE



17C. VITAMIN ENHANCED CHERRIES, COMMERCIAL PACKAGE



17D. VITAMIN ENHANCED CHERRIES, BARRIER PACKAGE

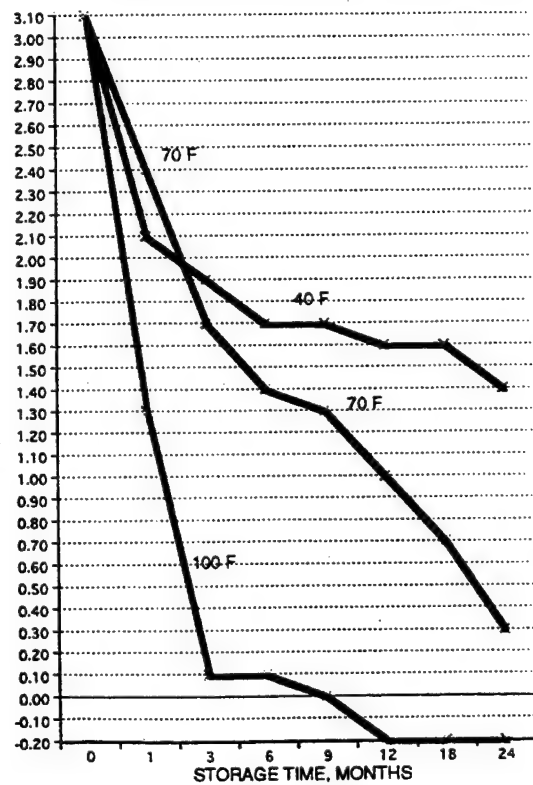


Fig. 17 - REFLECTANCE a VALUES OF NUTRIENT ENHANCED CHERRIES

## b Values

Table 21 contains the b value data. They are plotted in Figures 18 and 19.

There is an apparent decrease in the b values with storage time for both products at all storage temperatures, indicating a loss of yellow coloration. This is particularly noticeable at 100 °F storage. It is also more noticeable with the apples. Since the color changes do not appear to be affected strongly by the packaging material, the changes are related to the storage temperature, rather than the moisture loss.

**TABLE 21 - REFLECTANCE b VALUES FOR NUTRIENT ENHANCED FRUIT**

<u>Data</u>		<u>Storage</u>	<u>Storage Time, Months</u>							
<u>Description</u>	<u>Package</u>	<u>Temp. °F</u>	<u>0</u>	<u>1</u>	<u>3</u>	<u>6</u>	<u>9</u>	<u>12</u>	<u>18</u>	<u>24</u>
<b>A. Apples with Added Minerals</b>										
smoothed	commercial	40	18.6	17.9	17.9	17.3	16.8	16.8	17.7	17.7
actual	commercial	40	18.6	17.9	17.3	18.3	16.2	16.8	18.7	17.7
smoothed	barrier	40	18.6	17.6	17.6	17.6	17.1	17.1	17.7	17.7
actual	barrier	40	18.6	15.0	17.6	16.8	18.7	17.1	17.7	18.7
smoothed	commercial	70	18.6	17.1	17.1	17.1	16.0	16.0	15.7	15.7
actual	commercial	70	18.6	16.5	17.1	18.3	16.0	14.2	16.3	15.7
smoothed	barrier	70	18.6	17.3	16.8	16.8	16.8	16.1	16.0	14.9
actual	barrier	70	18.6	16.6	17.3	16.8	16.9	16.1	16.0	14.9
smoothed	commercial	100	18.6	17.8	17.8	17.8	16.0	15.2	14.2	14.1
actual	commercial	100	18.6	15.3	17.8	18.3	16.0	14.2	15.2	14.1
smoothed	barrier	100	18.6	16.8	15.7	14.3	13.0	10.3	9.4	7.1
actual	barrier	100	18.6	15.7	16.8	14.3	13.0	10.3	9.4	7.1
<b>B. Apples with Added Vitamins</b>										
smoothed	commercial	40	18.7	17.5	17.5	17.5	17.1	17.1	17.5	17.5
actual	commercial	40	18.7	15.1	17.5	18.2	16.8	17.1	17.5	18.8
smoothed	barrier	40	18.7	18.0	17.9	17.9	17.3	17.3	17.3	17.3
actual	barrier	40	18.7	18.0	17.9	17.2	18.2	16.9	17.3	18.7
smoothed	commercial	70	18.7	17.5	17.5	17.5	16.8	15.8	15.7	13.9
actual	commercial	70	18.7	16.8	17.5	18.0	16.8	15.7	15.8	13.9
smoothed	barrier	70	18.7	18.7	17.1	16.8	16.0	14.6	14.4	13.3
actual	barrier	70	18.7	18.9	17.1	16.8	16.0	14.6	14.4	13.3
smoothed	commercial	100	18.7	13.4	13.4	13.4	12.3	12.3	11.7	9.3
actual	commercial	100	18.7	12.9	13.4	14.7	12.3	11.7	12.6	9.3
smoothed	barrier	100	18.7	18.2	13.5	12.1	8.9	6.6	5.3	4.1
actual	barrier	100	18.7	18.2	13.5	12.1	8.9	6.6	5.3	4.1

(Continued)

**TABLE 21 -REFLECTANCE b VALUES FOR NUTRIENT ENHANCED FRUIT (Continued)**

**C. Cherries with Added Minerals**

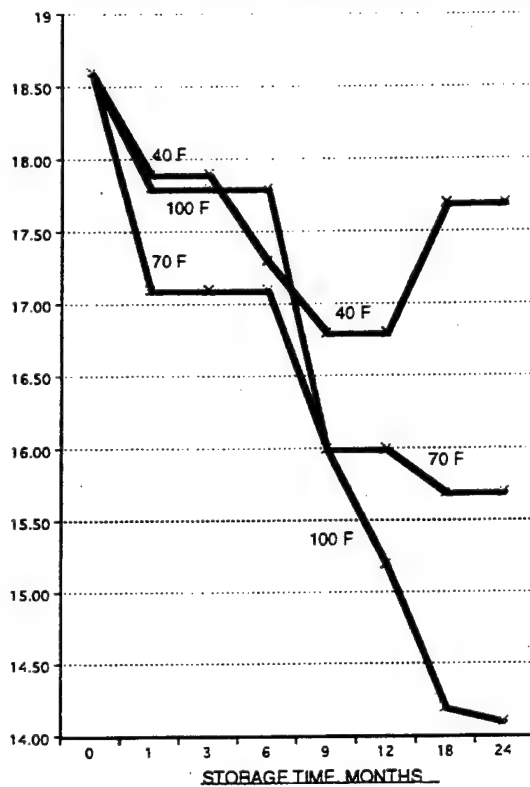
smoothed	commercial	40	0.7	0.3	0.3	0.4	0.4	0.4	0.2	0.1
actual	commercial	40	0.7	0.3	0.3	0.4	0.4	0.8	0.1	0.2
smoothed	barrier	40	0.7	0.4	0.3	0.3	0.5	0.5	0.5	0.5
actual	barrier	40	0.7	0.4	0.3	0.3	0.5	0.5	0.4	0.7
smoothed	commercial	70	0.7	0.7	0.5	0.4	0.4	0.4	0.2	0.2
actual	commercial	70	0.7	0.8	0.4	0.5	0.4	0.5	0.1	0.2
smoothed	barrier	70	0.7	0.7	0.6	0.5	0.5	0.5	0.5	0.4
actual	barrier	70	0.7	0.7	0.2	0.6	0.3	0.5	0.5	0.4
smoothed	commercial	100	0.7	0.3	0.3	0.3	0.5	0.5	0.5	-0.5
actual	commercial	100	0.7	0.3	0.0	0.6	0.3	0.5	0.5	-0.5
smoothed	barrier	100	0.7	0.3	0.3	0.5	0.7	0.7	0.7	-0.2
actual	barrier	100	0.7	0.3	-0.1	0.7	0.5	0.7	0.7	-0.2

**D. Cherries with Added Vitamins**

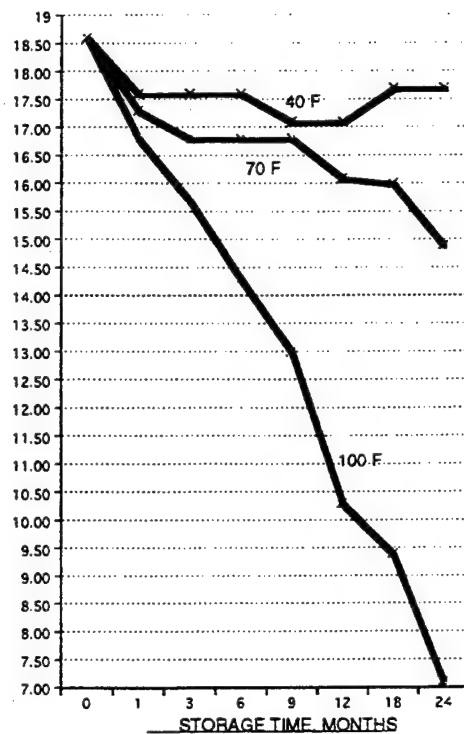
smoothed	commercial	40	0.8	0.3	0.3	0.3	0.3	0.3	0.1	0.0
actual	commercial	40	0.8	0.3	0.3	0.2	0.3	0.6	0.0	0.1
smoothed	barrier	40	0.8	0.2	0.1	0.1	0.1	0.1	0.3	0.3
actual	barrier	40	0.8	0.2	-0.2	0.1	0.2	0.3	-0.1	0.3
smoothed	commercial	70	0.8	0.4	0.3	0.3	0.2	0.2	0.1	-0.2
actual	commercial	70	0.8	0.4	0.3	0.2	0.3	0.2	0.1	-0.2
smoothed	barrier	70	0.8	0.5	0.5	0.3	0.3	0.3	0.2	0.1
actual	barrier	70	0.8	0.5	0.5	0.3	0.1	0.4	0.1	0.2
smoothed	commercial	100	0.8	0.4	-0.1	-0.3	-0.3	-0.3	-0.3	-0.4
actual	commercial	100	0.8	0.4	-0.1	-0.3	-0.4	-0.2	-0.3	-0.4
smoothed	barrier	100	0.8	0.2	-0.1	-0.2	-0.2	-0.2	0.1	0.2
actual	barrier	100	0.8	0.2	-0.2	-0.1	-0.2	-0.2	0.1	0.2



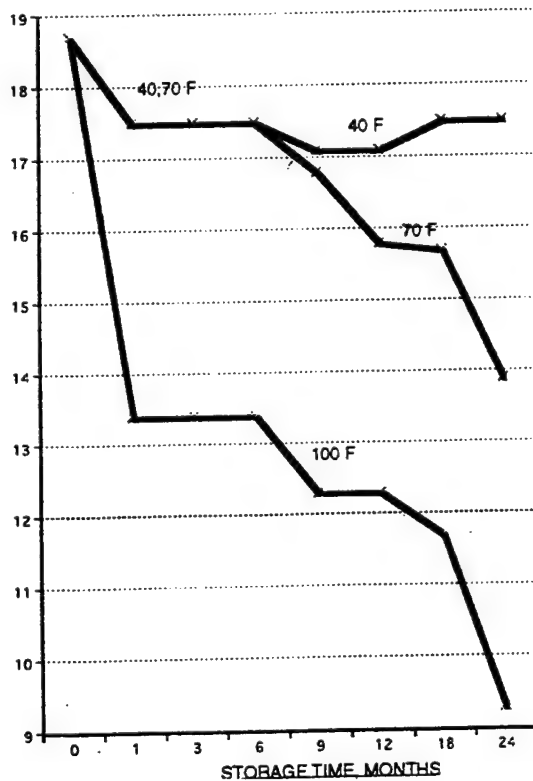
18A. MINERAL ENHANCED APPLES, COMMERCIAL PACKAGE



18B. MINERAL ENHANCED APPLES, BARRIER PACKAGE



18C. VITAMIN ENHANCED APPLES, COMMERCIAL PACKAGE



18D. VITAMIN ENHANCED APPLES, BARRIER PACKAGE

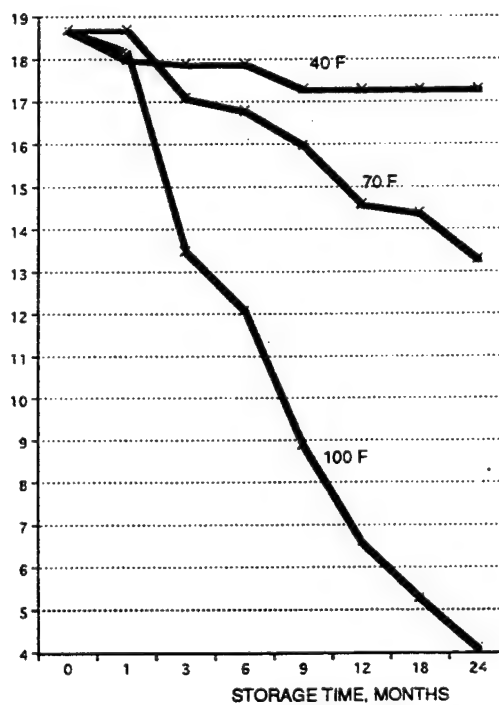
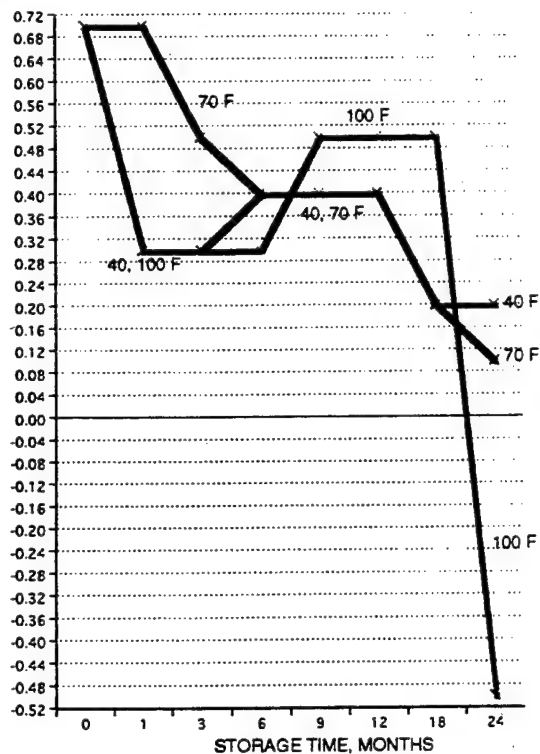
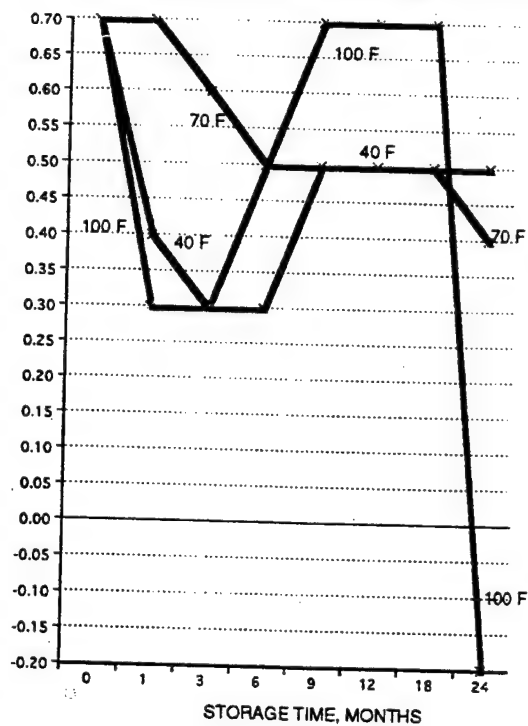


Fig. 18 - REFLECTANCE b VALUES OF NUTRIENT ENHANCED APPLES

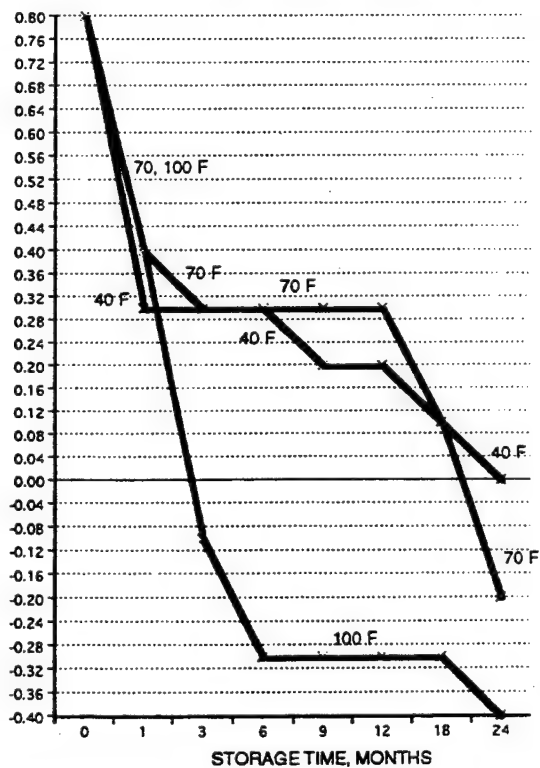
19A. MINERAL ENHANCED CHERRIES, COMMERCIAL PACKAGE



19B. MINERAL ENHANCED CHERRIES, BARRIER PACKAGE



19C. VITAMIN ENHANCED CHERRIES, COMMERCIAL PACKAGE



19D. VITAMIN ENHANCED CHERRIES, BARRIER PACKAGE

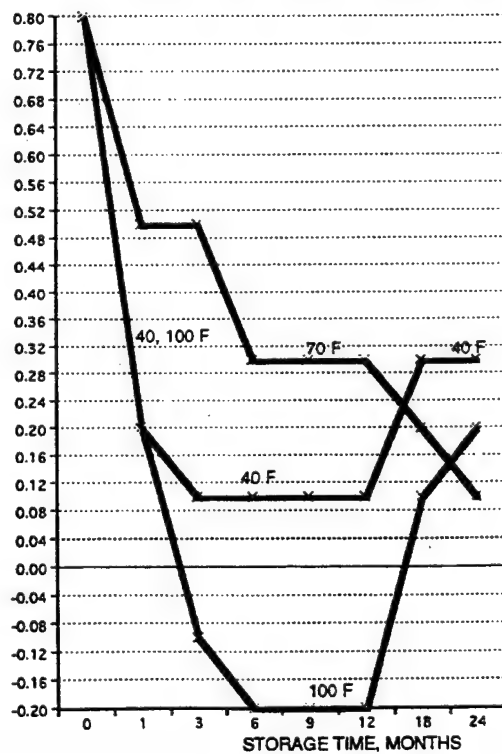


Fig. 19- REFLECTANCE b VALUES OF NUTRIENT ENHANCED CHERRIES

## Data Analysis

The data analysis for the results of the physical tests are contained in Table 22. This analysis is based on the smoothed data that has been transformed to reflect the deviation from the initial values.

**TABLE 22 - DATA ANALYSIS FOR NUTRIENT ENHANCED FRUIT**

Factor	Analysis									
	Aw		% Moist.		L		a		b	
	F	Sign.	F	Sign.	F	Sign.	F	Sign.	F	Sign.
<b>A. Apples</b>										
Time	1.18	nsd	0.06	nsd	1.78	0.19	1.68	nsd	0.00	nsd
Temperature	0.16	nsd	0.67	nsd	6.17	0.01	1.34	nsd	2.08	nsd
Package	0.03	nsd	0.29	nsd	2.38	nsd	0.28	nsd	0.86	nsd
Nutrient	0.25	nsd	0.02	nsd	1.04	nsd	1.63	nsd	1.89	nsd
Time x Temperature	1.18	nsd	0.41	nsd	4.57	0.05	2.96	nsd	0.03	nsd
Time x Package	1.76	nsd	0.27	nsd	0.53	nsd	0.16	nsd	0.06	nsd
Time x Nutrient	1.11	nsd	0.05	nsd	1.39	nsd	0.56	nsd	1.12	nsd
Temperature x Package	0.42	nsd	0.45	nsd	5.48	0.05	1.27	nsd	1.78	nsd
Temperature x Nutrient	0.18	nsd	0.02	nsd	4.96	0.05	3.27	nsd	3.81	0.05
Package x Nutrient	0.33	nsd	0.03	nsd	1.26	nsd	0.40	nsd	1.43	nsd
Time x Temperature x Package	1.31	nsd	0.65	nsd	1.84	nsd	0.53	nsd	0.05	nsd
Time x Temperature x Nutrient	0.35	nsd	0.28	nsd	2.74	nsd	0.91	nsd	0.33	nsd
Time x Package x Nutrient	0.96	nsd	0.22	nsd	0.85	nsd	0.01	nsd	0.25	nsd
Temperature x Package x Nutrient	0.03	nsd	0.00	nsd	3.14	nsd	1.51	nsd	2.95	nsd
Time x Temperature x Package x Nutrient	0.26	nsd	0.79	nsd	2.62	nsd	0.00	nsd	0.98	nsd
<b>B. Cherries</b>										
Time	4.32	0.05	0.08	nsd	0.43	nsd	0.56	nsd	0.06	nsd
Temperature	1.48	nsd	0.68	nsd	0.53	nsd	1.91	nsd	0.88	nsd
Package	1.95	nsd	0.36	nsd	0.46	nsd	0.20	nsd	0.20	nsd
Nutrient	4.19	0.05	0.08	nsd	0.77	nsd	0.01	nsd	0.54	nsd
Time x Temperature	8.18	0.01	0.56	nsd	1.28	nsd	0.52	nsd	0.05	nsd
Time x Package	3.95	0.05	0.00	nsd	0.28	nsd	0.70	nsd	0.14	nsd
Time x Nutrient	1.81	nsd	0.00	nsd	1.66	nsd	0.51	nsd	0.03	nsd
Temperature x Package	1.18	nsd	0.67	nsd	0.29	nsd	0.44	nsd	0.19	nsd
Temperature x Nutrient	3.30	nsd	0.01	nsd	0.69	nsd	0.43	nsd	1.55	nsd
Package x Nutrient	3.00	nsd	0.03	nsd	1.00	nsd	0.01	nsd	0.57	nsd
Time x Temperature x Package	6.06	0.05	0.01	nsd	0.44	nsd	0.86	nsd	0.00	nsd
Time x Temperature x Nutrient	2.59	nsd	0.00	nsd	1.44	nsd	0.70	nsd	0.02	nsd
Time x Package x Nutrient	1.52	nsd	0.14	nsd	1.17	nsd	0.76	nsd	0.08	nsd
Temperature x Package x Nutrient	2.86	nsd	0.06	nsd	0.60	nsd	0.17	nsd	0.44	nsd
Time x Temperature x Package x Nutrient	2.36	nsd	0.20	nsd	0.94	nsd	0.86	nsd	0.06	nsd

## NUTRIENT ENHANCED VEGETABLES

The purpose of this portion of the study was to determine if vegetables could be prepared that had nutrients infused during the osmotic drying process. Three vegetables were chosen - potatoes, carrots and celery. The minerals - Calcium (Ca), Magnesium (Mg), and Zinc (Zn) were added to a portion of each. The vitamins - Folic Acid and vitamin B<sub>12</sub> were added to another portion of each vegetable.

### Packaging

6 oz. (168 g) of the products were placed in the barrier pouch for storage.

### Storage

They were stored at 40, 70 and 100 °F and withdrawn at 1, 3 and 6 months for analysis. A small amount was also placed at 120 °F for one month for sensory evaluation.

## Results

### Nutrient Analyses

Nutrient analyses for the vitamins were done with each withdrawal. The mineral content was determined initially. This data is shown in Table 23. The data is the amount greater than in the product before addition. The data is recalculated to 100% dryness. The vitamin analyses are illustrated in Figure 20.

**TABLE 23 - NUTRIENT ANALYSIS OF NUTRIENT ENHANCED VEGETABLES**

	<u>Storage</u>	<u>Storage</u>	<u>Concentration, ppm</u> *				<u>Vitamin</u> <u>B12</u>
	<u>Time,</u>	<u>Temp.</u>	<u>Ca</u>	<u>Mg</u>	<u>Zn</u>	<u>Folic</u> <u>Acid</u>	
	<u>Months</u>	<u>°F</u>					
<u>A. Carrots</u>							
	initial	NA	900	580	24	32	**
	1	40	NA	NA	NA	43	
	1	70	NA	NA	NA	29	
	1	100	NA	NA	NA	12	
	3	40	NA	NA	NA	28	
	3	70	NA	NA	NA	30	
	3	100	NA	NA	NA	18	
	6	40	NA	NA	NA	13	
	6	70	NA	NA	NA	12	
	6	100	NA	NA	NA	3	

(Continued)

**TABLE 23 - NUTRIENT ANALYSIS OF NUTRIENT ENHANCED VEGETABLES (Continued)**

**B. Celery**

initial	NA	1170	620	29	6	**
1	40	NA	NA	NA	7	
1	70	NA	NA	NA	7	
1	100	NA	NA	NA	7	
3	40	NA	NA	NA	6	
3	70	NA	NA	NA	5	
3	100	NA	NA	NA	7	
6	40	NA	NA	NA	6	
6	70	NA	NA	NA	5	
6	100	NA	NA	NA	6	

**C. Potatoes**

initial	NA	750	500	20	34	**
1	40	NA	NA	NA	8	
1	70	NA	NA	NA	7	
1	100	NA	NA	NA	7	
3	40	NA	NA	NA	4	
3	70	NA	NA	NA	3	
3	100	NA	NA	NA	3	
6	40	NA	NA	NA	3	
6	70	NA	NA	NA	6	
6	100	NA	NA	NA	0	

\* The data is reported on a 100% dry basis

\*\* The analysis method found a small amount of vitamin B12 that was less than could be measured

The folic acid content of the vegetables before any nutrient addition was:

Carrots - 0.9; Celery - 0.9; Potatoes - 0.9 (ppm)

The mineral content of the vegetables before any nutrient addition was:

Carrots - Ca - 98, Mg - 45, Zn - 1.1;

Celery - Ca - 196, Mg - 23; Zn - 0.6;

Potatoes - Ca - 15, Mg - 28, Zn - 0.4

The vegetables all infused the vitamins quite readily. The carrots and potatoes also infused the folic acid. The celery less so. The carrots and celery maintained the folic acid well through three months of storage at 40 and 70 °F. The carrots lost most of the folic acid after three months. They also had a large loss of folic acid at 100 °F storage. The celery did not show any losses at up to six months storage. The potatoes lost most of the folic acid as early as one month.

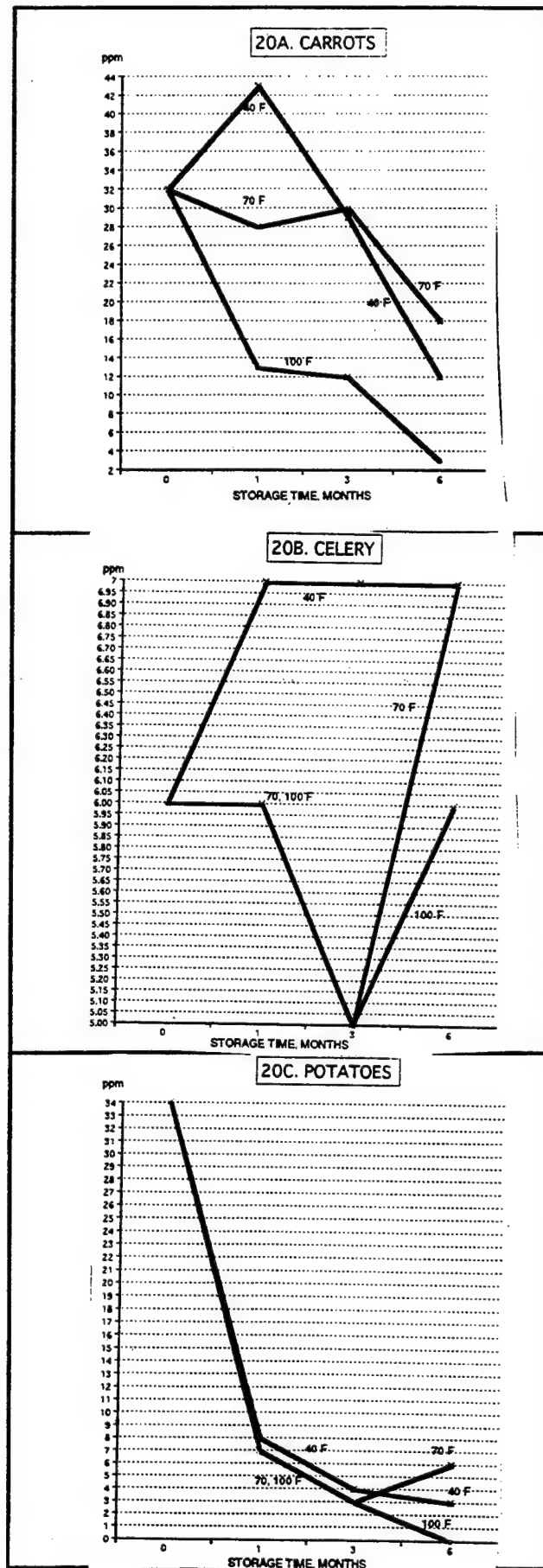


Fig. 20 - FOLIC ACID CONTENT OF NUTRIENT ENHANCED VEGETABLES

## Sensory Testing -

### Consumer Panel

The consumer panel rated the mineral infused vegetables separately from the vitamin infused vegetables. The products were tested initially with no storage time. Because these initial results were poor the test was not repeated. The results are contained in Table 24. The vegetables for the sensory panels were all rehydrated by soaking in gentle boiling tap water for 10 minutes.

**TABLE 24 - CONSUMER PANEL SCORES OF NUTRIENT ENHANCED VEGETABLES**

Score	Product					
	Carrots		Potatoes		Celery	
			Infusion			
	Mineral	Vitamin	Mineral	Vitamin	Mineral	Vitamin
Number of Scores						
<b>A. Overall Acceptability</b>						
9	2	0	0	0	0	0
8	4	4	2	0	2	1
7	11	5	2	2	4	5
6	7	4	6	3	11	4
5	6	5	6	7	5	3
4	7	4	9	9	10	8
3	1	10	5	9	1	7
2	0	4	6	3	4	4
1	0	1	2	4	1	5
N	38	37	38	37	38	37
Mean	6.1	4.6	4.2	3.8	4.9	4.0
SD	1.5	2.1	1.8	1.6	1.7	2.0
<b>B. Flavor</b>						
9	2	1	0	0	0	0
8	4	4	2	0	1	1
7	10	3	3	2	6	7
6	6	5	4	4	8	4
5	5	2	4	7	9	6
4	9	6	10	5	7	5
3	2	5	7	11	3	5
2	0	8	2	4	2	4
1	0	3	6	4	2	5
N	38	37	38	37	38	37
Mean	5.9	4.3	4.0	3.7	4.9	4.3
SD	1.7	2.4	2.0	1.7	1.7	2.1

(Continued)

TABLE 24 - CONSUMER PANEL SCORES OF NUTRIENT ENHANCED VEGETABLES

(Continued)

C. Color

9	1	1	0	0	0	0
8	15	7	5	4	8	6
7	13	11	10	7	10	10
6	6	4	7	4	7	2
5	1	4	6	10	8	10
4	1	5	5	7	2	4
3	1	2	4	3	1	2
2	0	2	0	1	1	1
1	0	1	1	1	1	2
N	38	37	38	37	38	37
Mean	7.1	5.9	5.7	5.3	6.1	5.6
SD	1.2	2.0	1.7	1.7	1.7	2.0

D. Texture

9	1	0	0	0	0	0
8	7	4	0	1	1	1
7	15	6	6	3	10	5
6	6	7	9	4	6	7
5	4	7	5	7	6	7
4	4	8	9	9	9	6
3	1	3	1	6	3	4
2	0	1	6	5	0	3
1	0	1	2	2	3	4
N	38	37	38	37	38	37
Mean	6.5	5.3	4.6	4.2	5.1	4.5
SD	1.4	1.7	1.8	1.0	1.8	2.0

The data analysis for the consumer panel scores is contained in Table 25.

The vitamin infused carrots was significantly better in all characteristics than the mineral infused carrots. There were no differences between the potatoes. The overall acceptability of the vitamin infused celery was better than the mineral infused celery, but there were no differences for the other characteristics. Only the vitamin infused carrots gave an overall acceptability rating that was acceptable.

Because the vegetables were prepared for use as an ingredient in soups or stews, the sensory results were not surprising. One month storage tests were not conducted.

TABLE 25 - DATA ANALYSIS FOR CONSUMER PANEL SCORES OF NUTRIENT ENHANCED VEGETABLES

	Characteristic							
	Overall		Flavor		Color		Texture	
	<u>F</u>	<u>Sign.</u>	<u>F</u>	<u>Sign.</u>	<u>F</u>	<u>Sign.</u>	<u>F</u>	<u>Sign.</u>
Carrots	11.7	0.01	10.8	0.01	9.7	0.01	10.4	0.01
Potatoes	2.4	nsd	0.4	nsd	0.9	nsd	1.0	nsd
Celery	4.5	0.05	1.8	nsd	1.3	nsd	1.7	nsd



### Technical Panel

As the consumer panel scores were unacceptable, technical panels were not run on these products

### Physical Analyses

Actual and smoothed data are contained in Tables 26 - 30. Smoothed data are plotted in Figures 21 - 25.

### Water Activity

The water activity of the nutrient enhanced vegetables is contained in Table 26 and plotted in Fig. 21.

**TABLE 26 - WATER ACTIVITY OF NUTRIENT ENHANCED VEGETABLES**

Added Nutrient	Storage Temp. °F	Values After Storage Time, Months							
		0		1		3		6	
		actual	smooth	actual	smooth	actual	smooth	actual	smooth
A. Carrots									
vitamins	40	0.66	0.66	0.66	0.66	0.68	0.66	0.65	0.65
vitamins	70	0.66	0.66	0.66	0.66	0.66	0.66	0.65	0.65
vitamins	100	0.66	0.66	0.67	0.66	0.64	0.64	0.63	0.63
minerals	40	0.71	0.71	0.66	0.67	0.67	0.66	0.64	0.64
minerals	70	0.71	0.71	0.70	0.71	0.71	0.70	0.67	0.67
minerals	100	0.71	0.71	0.68	0.68	0.64	0.68	0.68	0.64
B. Celery									
vitamins	40	0.54	0.54	0.54	0.54	0.51	0.51	0.45	0.45
vitamins	70	0.54	0.54	0.56	0.54	0.49	0.49	0.48	0.48
vitamins	100	0.54	0.54	0.55	0.54	0.45	0.45	0.44	0.44
minerals	40	0.54	0.54	0.54	0.54	0.51	0.51	0.46	0.46
minerals	70	0.54	0.54	0.57	0.54	0.49	0.51	0.51	0.49
minerals	100	0.54	0.54	0.58	0.54	0.50	0.50	0.48	0.48
C. Potatoes									
vitamins	40	0.60	0.60	0.62	0.60	0.55	0.55	0.51	0.51
vitamins	70	0.60	0.60	0.61	0.60	0.54	0.54	0.52	0.52
vitamins	100	0.60	0.60	0.61	0.60	0.56	0.56	0.51	0.51
minerals	40	0.60	0.60	0.63	0.60	0.55	0.55	0.52	0.52
minerals	70	0.60	0.60	0.61	0.60	0.58	0.58	0.58	0.58
minerals	100	0.60	0.60	0.63	0.60	0.56	0.56	0.54	0.54

There was a lessening of the water activity with storage time for all the vegetables but no correlation with storage temperature.

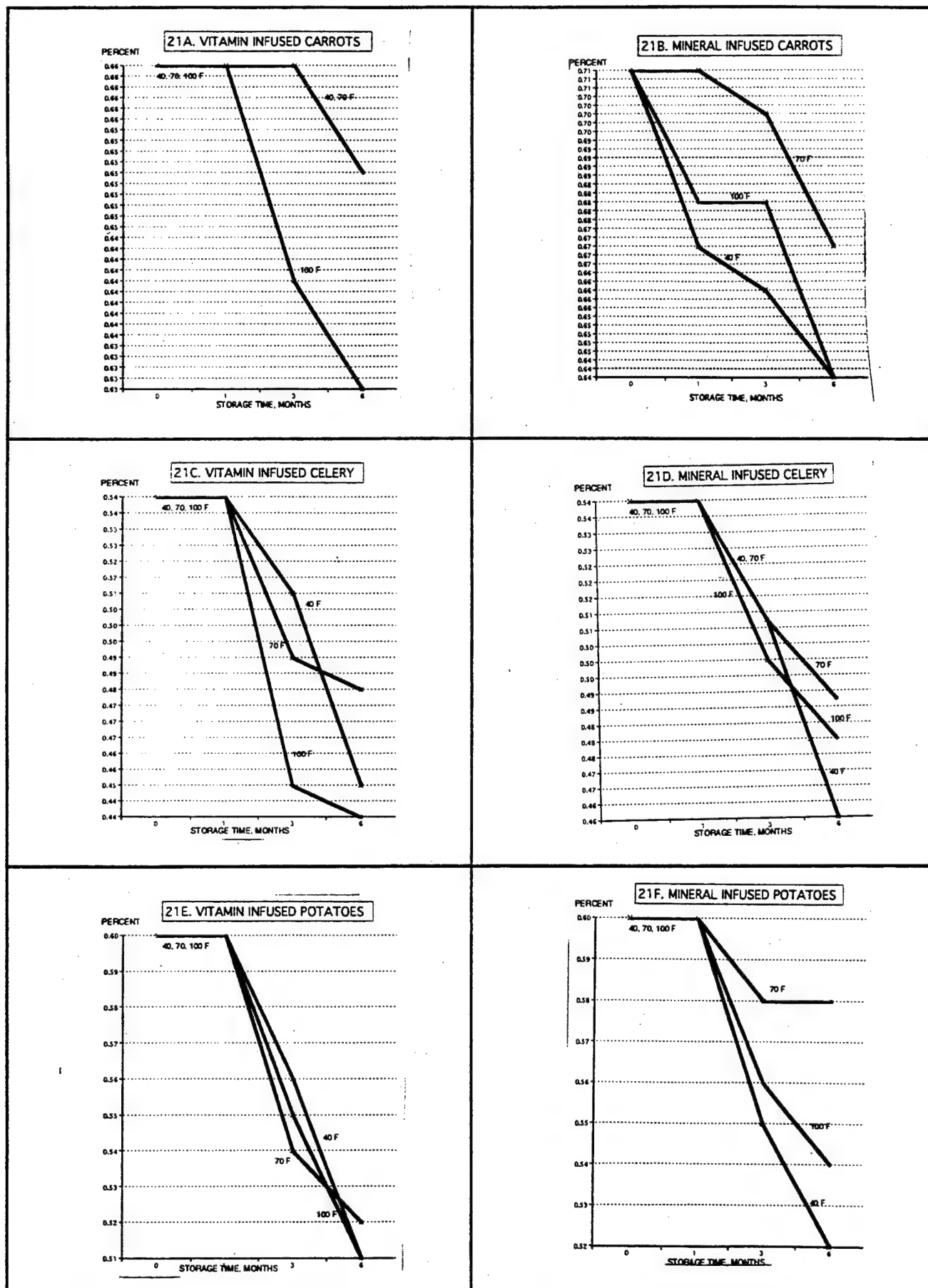


Fig. 21 - WATER ACTIVITY OF NUTRIENT ENHANCED VEGETABLES

## Percent Moisture

The percent moisture of the nutrient enhanced vegetables is contained in Table 27 and plotted in Figure 22. The radiant heating method was used. Both actual and smoothed data are shown.

**TABLE 27 - PERCENT MOISTURE OF NUTRIENT ENHANCED VEGETABLES**

Added Nutrient	Storage Temp. °F	Values After Storage Time, Months							
		0		1		3		6	
		actual	smooth	actual	smooth	actual	smooth	actual	smooth
<b>A. Carrots</b>									
vitamins	40	10.5	10.5	9.1	9.1	8.8	8.8	10.3	8.8
vitamins	70	10.5	10.5	10.9	10.5	10.1	10.1	10.0	10.0
vitamins	100	10.5	10.5	9.1	9.8	9.8	9.6	9.6	9.6
minerals	40	13.7	13.7	11.4	11.4	11.0	11.4	11.7	11.0
minerals	70	13.7	13.7	14.3	13.7	13.4	13.4	12.5	12.5
minerals	100	13.7	13.7	5.9	13.7	14.9	13.6	13.6	13.6
<b>B. Celery</b>									
vitamins	40	5.8	5.8	6.4	5.8	5.3	5.6	5.6	5.3
vitamins	70	5.8	5.8	6.3	6.2	6.2	6.2	5.3	5.3
vitamins	100	5.8	5.8	7.6	7.1	7.1	7.1	5.2	5.2
minerals	40	8.1	8.1	9.1	8.1	6.3	7.6	7.6	6.3
minerals	70	8.1	8.1	8.5	8.2	8.2	8.2	7.4	7.4
minerals	100	8.1	8.1	3.9	8.1	9.2	8.1	8.7	8.1
<b>C. Potatoes</b>									
vitamins	40	8.2	8.2	5.9	5.9	4.2	5.3	5.3	4.2
vitamins	70	8.2	8.2	7.2	7.2	5.3	5.3	4.8	4.8
vitamins	100	8.2	8.2	8.5	8.2	8.0	8.0	6.3	6.3
minerals	40	8.3	8.3	5.7	5.7	3.5	4.2	4.2	3.5
minerals	70	8.3	8.3	8.5	8.3	6.5	8.3	10.9	6.5
minerals	100	8.3	8.3	4.5	7.8	7.8	7.8	8.3	4.5

The moisture content generally lessened with storage time with all the vegetables. As with the water activity there was no correlation with storage temperature.

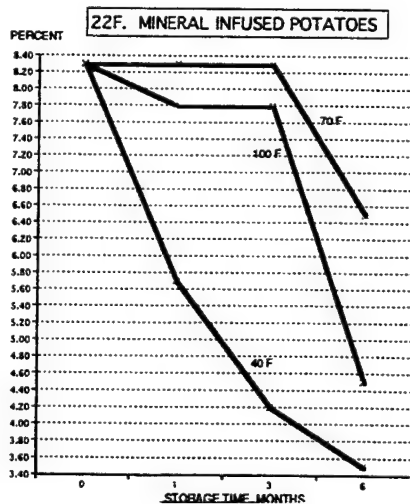
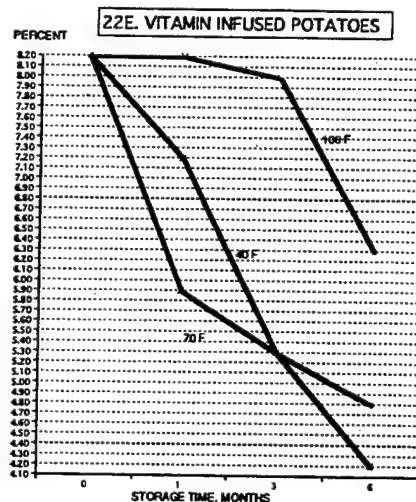
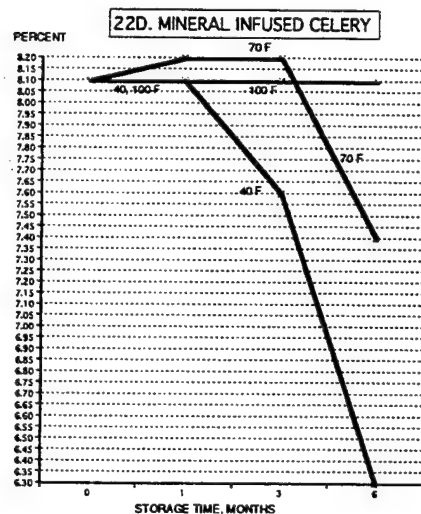
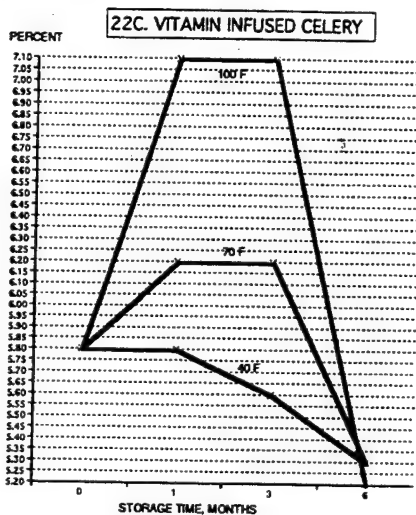
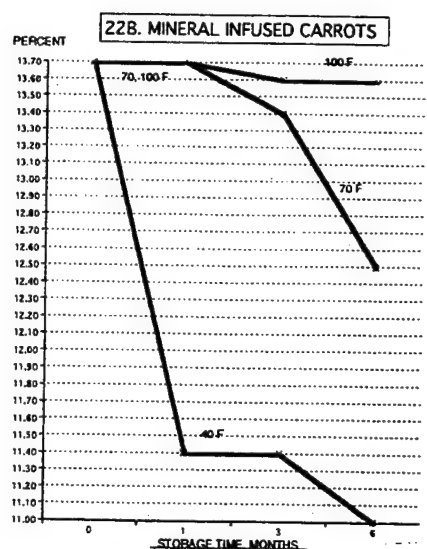
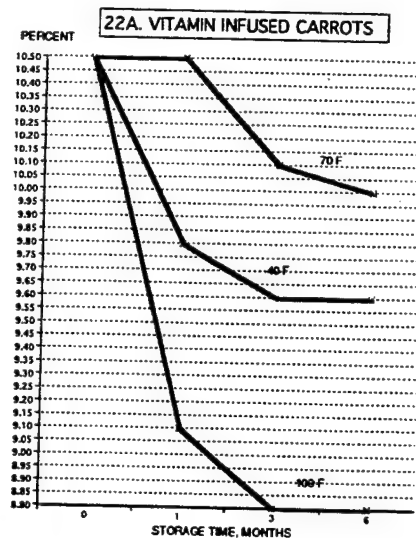


Fig. 22- MOISTURE CONTENT OF NUTRIENT ENHANCED VEGETABLES

## Reflectance

### L Values

The L values are contained in Table 28 and plotted in Figure 23.

**TABLE 28 - REFLECTANCE L VALUES OF NUTRIENT ENHANCED VEGETABLES**

Added Nutrient	Storage Temp. °F	Values After Storage Time, Months							
		0		1		3		6	
		actual	smooth	actual	smooth	actual	smooth	actual	smooth
A. Carrots									
vitamins	40	27.3	27.3	28.7	28.4	28.4	28.4	27.4	27.4
vitamins	70	27.3	27.3	29.3	29.3	30.7	29.3	26.7	26.7
vitamins	100	27.3	27.3	29.3	29.3	29.8	29.3	25.2	25.2
minerals	40	30.5	30.5	25.8	30.3	30.3	30.3	28.1	28.1
minerals	70	30.5	30.5	29.9	30.5	31.6	30.9	30.9	31.6
minerals	100	30.5	30.5	31.1	30.5	29.5	29.5	26.2	26.2
B. Celery									
vitamins	40	27.4	27.4	25.3	27.2	27.2	27.2	27.8	27.2
vitamins	70	27.4	27.4	24.5	27.4	28.1	28.1	28.9	28.1
vitamins	100	27.4	27.4	26.5	27.4	30.2	27.1	27.1	27.1
minerals	40	27.6	27.6	23.7	27.6	27.9	27.8	27.8	27.8
minerals	70	27.6	27.6	25.1	27.6	27.9	27.9	27.9	27.9
minerals	100	27.6	27.6	26.5	27.6	29.0	27.9	27.9	27.9
C. Potatoes									
vitamins	40	46.6	46.6	46.4	46.4	44.6	46.4	47.1	47.1
vitamins	70	46.6	46.6	48.2	46.6	44.3	44.3	44.1	44.1
vitamins	100	46.6	46.6	46.2	46.2	37.8	37.8	32.4	32.4
minerals	40	46.9	46.9	45.1	46.6	46.6	45.4	45.4	45.4
minerals	70	46.9	46.9	48.4	46.9	46.7	46.7	45.7	45.7
minerals	100	46.9	46.9	45.6	45.6	41.6	41.6	34.8	34.8

The carrots and potatoes darkened with storage time. The celery did not change. There was no correlation with storage temperature.

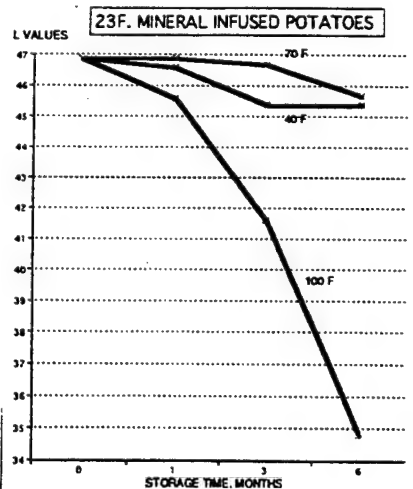
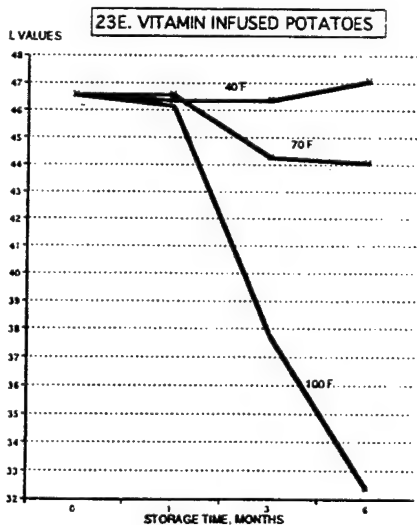
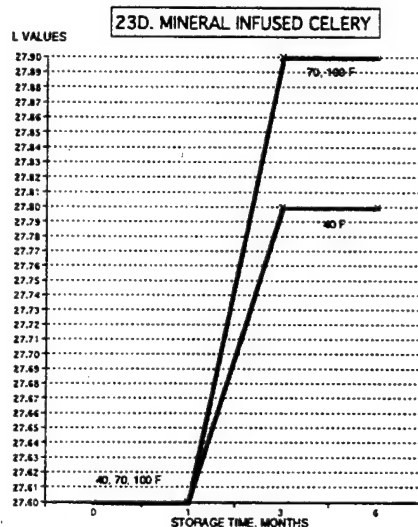
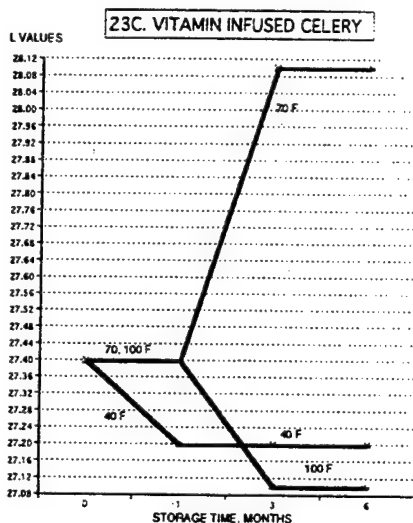
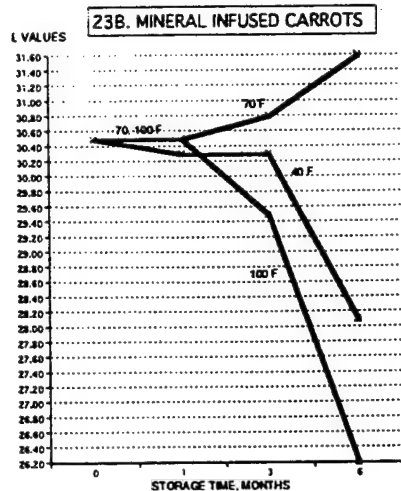
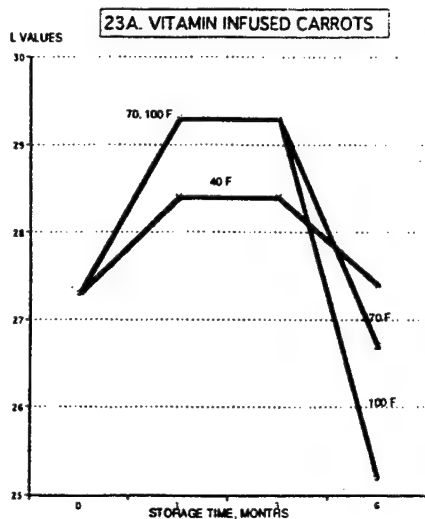


Fig. 23 - REFLECTANCE L VALUES OF NUTRIENT ENHANCED VEGETABLES

### a Values

The a values are contained in Table 29 and plotted in Figure 24.

**TABLE 29 - REFLECTANCE a VALUES OF NUTRIENT ENHANCED VEGETABLES**

Added Nutrient	Storage Temp. °F	Values After Storage Time, Months							
		0		1		3		6	
		actual	smooth	actual	smooth	actual	smooth	actual	smooth
<b>A. Carrots</b>									
vitamins	40	19.7	19.7	21.5	20.3	20.3	21.5	21.6	21.6
vitamins	70	19.7	19.7	19.1	19.1	19.1	19.1	19.6	19.1
vitamins	100	19.7	19.7	17.5	17.5	16.2	16.2	15.4	15.4
minerals	40	22.5	22.5	22.6	22.5	21.6	21.6	19.7	19.7
minerals	70	22.5	22.5	19.3	19.3	17.0	19.2	19.2	17.0
minerals	100	22.5	22.5	17.8	17.8	14.9	14.9	14.5	14.5
<b>B. Celery</b>									
vitamins	40	-2.7	-2.7	-2.3	-2.3	-2.2	-2.2	-1.6	-1.6
vitamins	70	-2.7	-2.7	-1.3	-1.4	-1.3	-1.3	-1.0	-1.0
vitamins	100	-2.7	-2.7	-0.7	-0.7	+0.1	+0.1	+0.2	+0.2
minerals	40	-2.2	-2.2	-1.6	-1.6	-1.3	-1.3	-0.9	-0.9
minerals	70	-2.2	-2.2	-1.3	-1.3	-0.5	-0.5	-0.5	-0.5
minerals	100	-2.2	-2.2	-0.3	-0.3	+0.3	+0.3	+0.7	+0.7
<b>C. Potatoes</b>									
vitamins	40	0.7	0.7	1.1	1.1	1.7	1.7	1.7	1.7
vitamins	70	0.7	0.7	1.0	1.0	2.7	2.7	3.2	3.2
vitamins	100	0.7	0.7	2.4	2.4	7.1	7.1	7.7	7.7
minerals	40	0.5	0.5	0.8	0.5	0.5	0.5	2.0	2.0
minerals	70	0.5	0.5	0.5	0.5	1.3	1.3	1.4	1.4
minerals	100	0.5	0.5	1.9	1.9	5.5	5.5	8.4	8.4

The carrots showed a general decrease in these values (a reddening) except for the vitamin infused carrots at 40 °F storage. Both the celery and potatoes showed an increase in a values for all storage temperatures.

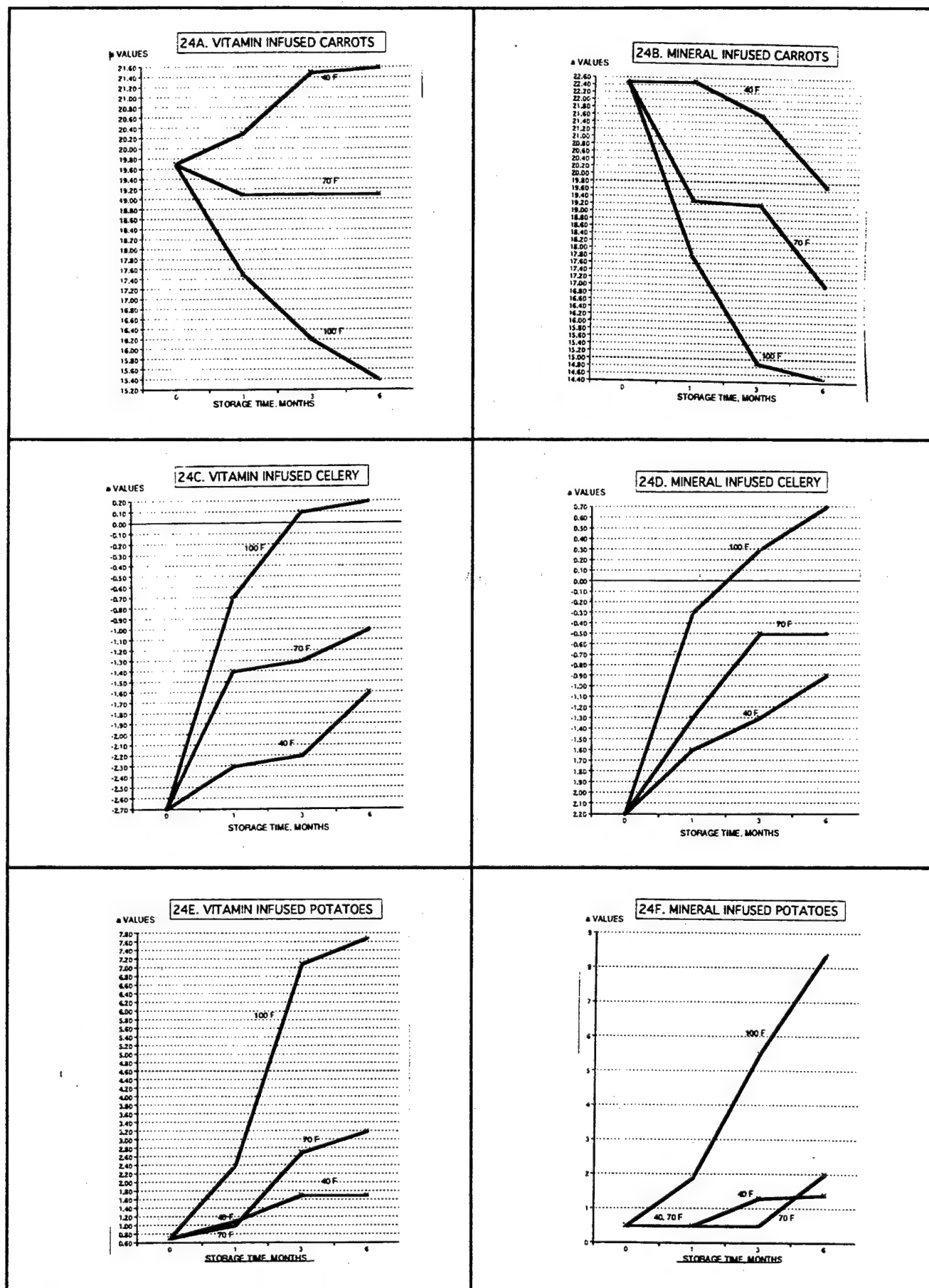


Fig. 24 - REFLECTANCE a VALUES OF NUTRIENT ENHANCED VEGETABLES



## b Values

The b values are contained in Table 30 and plotted in Figure 25.

**TABLE 30 - REFLECTANCE b VALUES OF NUTRIENT ENHANCED VEGETABLES**

Added nutrient	Storage Temp. °F	Values After Storage Time, Months							
		0		1		3		6	
		actual	smooth	actual	smooth	actual	smooth	actual	smooth
A. Carrots									
vitamins	40	10.7	10.7	11.5	11.5	11.6	11.6	12.5	12.5
vitamins	70	10.7	10.7	11.3	11.3	11.8	11.8	12.7	12.7
vitamins	100	10.7	10.7	12.3	10.7	10.5	10.8	10.8	10.8
minerals	40	12.3	12.3	11.2	12.3	12.6	11.5	11.5	11.5
minerals	70	12.3	12.3	11.1	11.1	10.7	11.1	12.2	10.7
minerals	100	12.3	12.3	13.0	12.3	9.3	9.6	9.6	9.3
B. Celery									
vitamins	40	7.6	7.6	8.6	8.4	8.4	8.6	8.9	8.9
vitamins	70	7.6	7.6	8.5	7.6	7.4	8.5	9.2	9.2
vitamins	100	7.6	7.6	10.1	8.2	8.2	8.2	7.5	7.5
minerals	40	8.3	8.3	8.2	8.2	8.1	8.2	8.3	8.2
minerals	70	8.3	8.3	8.6	8.3	7.1	8.4	8.4	8.4
minerals	100	8.3	8.3	8.5	8.3	7.4	7.9	7.9	7.4
C. Potatoes									
vitamins	40	14.0	14.0	16.4	14.9	14.9	15.0	15.0	15.0
vitamins	70	14.0	14.0	15.7	14.8	14.8	15.7	16.5	16.5
vitamins	100	14.0	14.0	15.9	14.0	13.0	13.0	11.4	11.4
minerals	40	14.0	14.0	14.6	14.0	13.4	14.6	14.9	14.9
minerals	70	14.0	14.0	13.0	14.0	14.9	14.4	14.4	14.4
minerals	100	14.0	14.0	15.5	14.5	14.5	14.5	12.8	14.5

There was no general trend for b values with the vegetables.

## Data Analysis

The data analysis for this portion of the study is contained in Table 31. The analysis was done with the smoothed data.

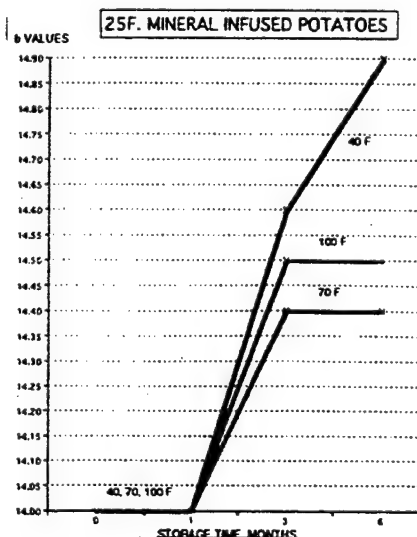
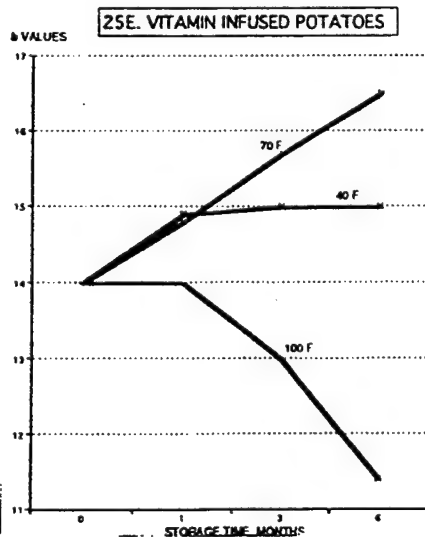
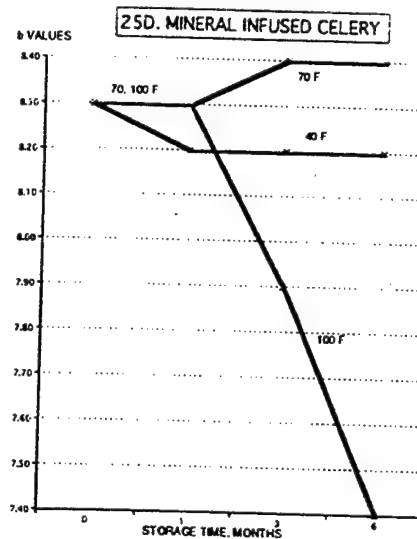
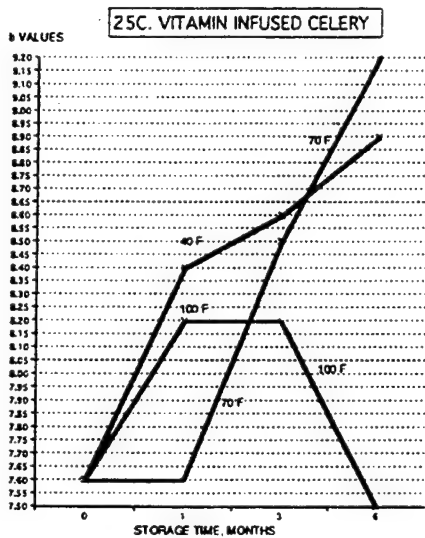
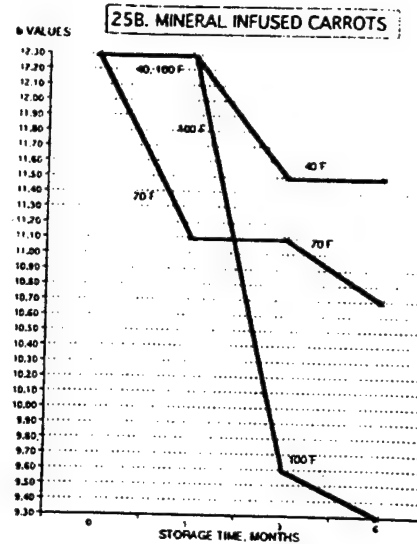
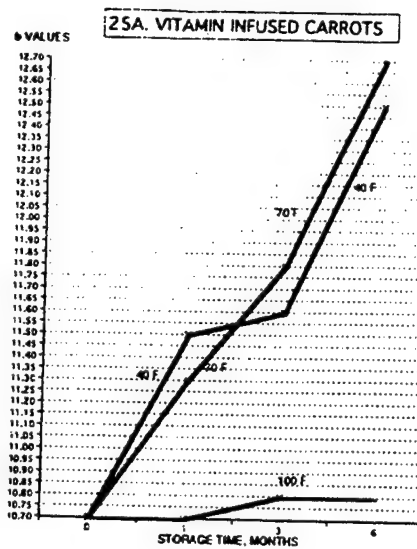


Fig. 25 - REFLECTANCE b VALUES OF NUTRIENT ENHANCED VEGETABLES

TABLE 31 - DATA ANALYSIS FOR NUTRIENT ENHANCED VEGETABLES

A. Analysis of Variance

Factor	Analysis					
	Aw		% Moist.		L	
	F	Sign.	F	Sign.	F	Sign.
<u>a. Carrots</u>						
Time	0.16	nsd	0.00	nsd	0.04	nsd
Temperature	0.14	nsd	0.14	nsd	0.59	nsd
Nutrient	0.82	nsd	1.06	nsd	0.05	nsd
Time x Temp.	0.13	nsd	0.00	nsd	0.63	nsd
Time x Nutrient	0.29	nsd	0.08	nsd	0.02	nsd
Temp. x Nutrient	0.31	nsd	1.33	nsd	0.25	nsd
Time x Temp. x Nutrient	0.02	nsd	0.02	nsd	0.09	nsd
<u>b. Celery</u>						
Time	0.41	nsd	8.25	nsd	0.15	nsd
Temperature	0.24	nsd	20.8	0.001	0.09	nsd
Nutrient	0.03	nsd	8.17	0.05	0.08	nsd
Time x Temp.	0.11	nsd	16.5	0.01	0.16	nsd
Time x Nutrient	0.03	nsd	15.2	0.01	0.06	nsd
Temp. x Nutrient	0.06	nsd	15.9	0.01	0.05	nsd
Time x Temp. x Nutrient	0.23	nsd	19.5	0.01	0.13	nsd
<u>c. Potatoes</u>						
Time	0.86	nsd	0.16	nsd	1.77	nsd
Temperature	0.03	nsd	0.25	nsd	0.07	nsd
Nutrient	0.00	nsd	0.01	nsd	0.00	nsd
Time x Temp.	0.08	nsd	0.03	nsd	4.34	nsd
Time x Nutrient	0.02	nsd	0.04	nsd	0.31	nsd
Temp. x Nutrient	0.03	nsd	0.06	nsd	0.00	nsd
Time x Temp. x Nutrient	0.17	nsd	0.12	nsd	0.62	nsd

B. Correlation

Factors	Carrots		Celery		Potatoes	
	r	Sign.	r	Sign.	r	Sign.
Aw x Percent Moisture	0.37	nsd	0.35	nsd	0.66	0.05
Aw x L	0.79	0.01	0.01	nsd	0.49	nsd
Aw x a	0.53	0.05	0.22	nsd	0.46	nsd
Aw x b	0.53	0.05	0.09	nsd	0.03	nsd
Percent Moisture x L	0.09	nsd	0.16	nsd	0.05	nsd
Percent Moisture x a	0.48	nsd	0.23	nsd	0.03	nsd
Percent Moisture x b	0.24	nsd	0.11	nsd	0.34	nsd
L x a	0.55	0.05	0.07	nsd	0.95	nsd
L x b	0.52	0.05	0.01	nsd	0.58	nsd
a x b	0.82	0.01	0.40	nsd	0.48	nsd

The carrots showed some differences in the a values. They tended to become more red with storage time. The celery showed some differences in the percent moisture content. They lost moisture on storage. They also showed a reddening with storage temperature.

Potatoes showed a correlation The for activity and moisture content. Carrots showed a correlation between the water activity and the reflectance values. They also showed a correlation among the reflectance values. The potatoes also showed a correlation between L and a, and L and b.

#### **NUTRIENT ENHANCED CRANBERRIES**

The purpose of this experiment was to determine if another osmotically dried fruit, cranberries, prepared with added nutrients would be acceptable for inclusion with MRE meals.

##### **Nutrients**

The cranberries were prepared with either added minerals or vitamins. The minerals added were Calcium (Ca), Magnesium (Mg) and Zinc (Zn). The mineral content was Ca - 810 ppm; Mg - 500 ppm; Zn - 21 ppm. Only folic acid as a vitamin was added for sensory testing. From the experiments with the added vegetables, vitamin B12 could not be determined at the level of infusion compatible with the minimum RDA. It was also felt that it was not really lacking in the diet of the soldier. Nonetheless, a small quantity of cranberries were prepared with a level five times that required and used for physical testing after being placed in storage.

##### **Packaging**

Two oz. (56 g) of cranberries were placed in the barrier pouch for this study.

##### **Storage**

The products were placed at 40, 70 and 100 °F for storage and withdrawn at 1, 3 and 6 months for analysis.

##### **Results**

**Physical Analyses** - Actual and smoothed data are shown in tables 32 to 36. Smoothed data are illustrated in figures 26 to 30.

### Water Activity

Table 32 contains the water activity data. They are plotted in Figure 26.

**TABLE 32 - WATER ACTIVITY OF NUTRIENT ENHANCED CRANBERRIES**

Added Nutrient	Storage Temp. °F	Storage Time, Months							
		0		1		3		6	
		actual	smooth	actual	smooth	actual	smooth	actual	smooth
minerals	40	0.55	0.55	0.59	0.55	0.39	0.39	0.30	0.30
minerals	70	0.55	0.55	0.57	0.55	0.39	0.39	0.36	0.36
minerals	100	0.55	0.55	0.55	0.55	0.40	0.40	0.36	0.36
vitamins*	40	0.53	0.53	0.60	0.53	0.49	0.49	0.40	0.40
vitamins*	70	0.53	0.53	0.54	0.53	0.36	0.44	0.40	0.40
vitamins*	100	0.53	0.53	0.52	0.52	0.35	0.44	0.44	0.35
vitamins	40	0.49	0.49	0.53	0.49	0.38	0.38	0.31	0.31
vitamins	70	0.49	0.49	0.52	0.49	0.44	0.44	0.29	0.29
vitamins	100	0.49	0.49	0.50	0.49	0.44	0.44	0.20	0.20
none	40	0.59	0.59	0.60	0.59	0.43	0.43	0.41	0.41
none	70	0.59	0.59	0.58	0.58	0.41	0.41	0.34	0.34
none	100	0.59	0.59	0.56	0.56	0.43	0.43	0.38	0.38

\* Greater amount of Vitamin B<sub>12</sub>

There was a significant decrease of water activity with storage time. No other effects were shown.

### Percent Moisture

Table 33 contains the percent moisture data. They are plotted in Figure 27.

**TABLE 33 - MOISTURE CONTENT OF NUTRIENT ENHANCED CRANBERRIES**

Added Nutrient	Storage Temp. °F	Storage Time, Months							
		0		1		3		6	
		actual	smooth	actual	smooth	actual	smooth	actual	smooth
minerals	40	16.1	16.1	11.7	11.7	8.8	11.7	12.8	8.8
minerals	70	16.1	16.1	10.9	10.9	8.7	10.4	10.4	8.7
minerals	100	16.1	16.1	8.5	8.5	7.5	8.5	10.8	7.5
vitamins*	40	12.6	12.6	12.0	12.0	10.7	10.7	10.3	10.3
vitamins*	70	12.6	12.6	10.6	10.6	7.8	10.6	10.9	7.8
vitamins*	100	12.6	12.6	8.3	9.5	9.5	9.5	9.9	9.5
vitamins	40	8.6	8.6	9.4	9.4	12.6	9.5	9.5	9.5
vitamins	70	8.6	8.6	10.4	10.3	10.3	10.3	9.4	9.4
vitamins	100	8.6	8.6	8.8	8.8	10.9	8.8	8.8	8.8
none	40	12.3	12.3	13.5	12.3	11.9	12.3	13.0	11.9
none	70	12.3	12.3	11.0	12.3	12.4	12.4	12.4	12.4
none	100	12.3	12.3	12.0	12.0	11.0	12.0	12.5	11.0

\* Greater amount of Vitamin B<sub>12</sub>

There were no effect of storage conditions on moisture loss.

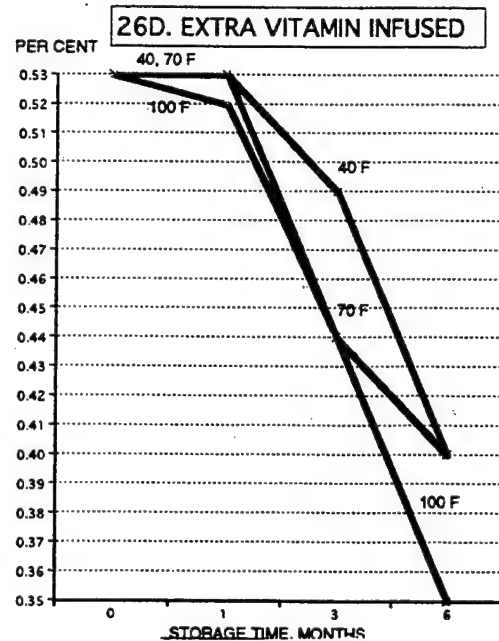
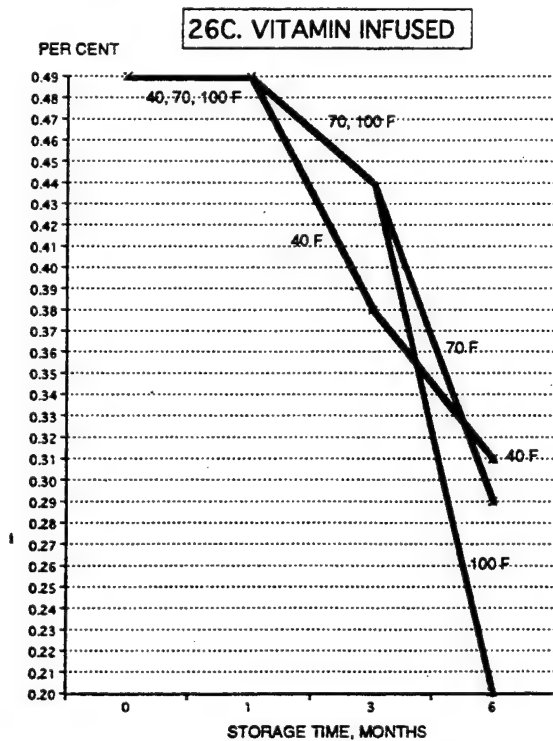
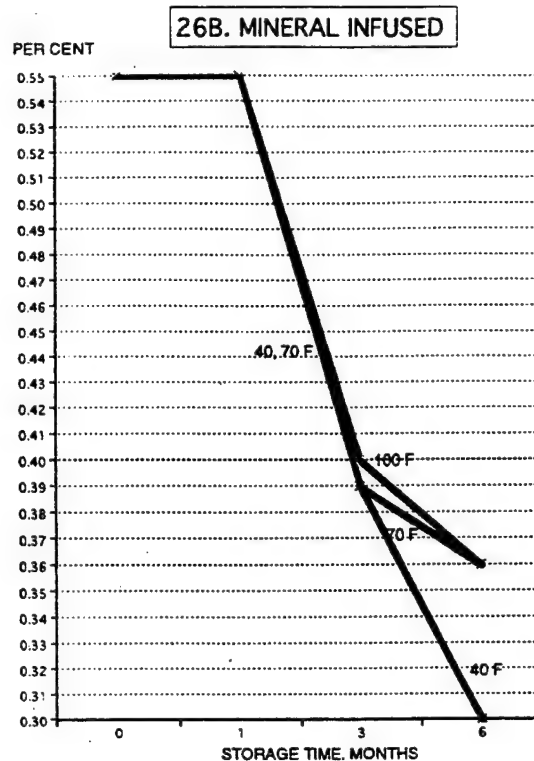
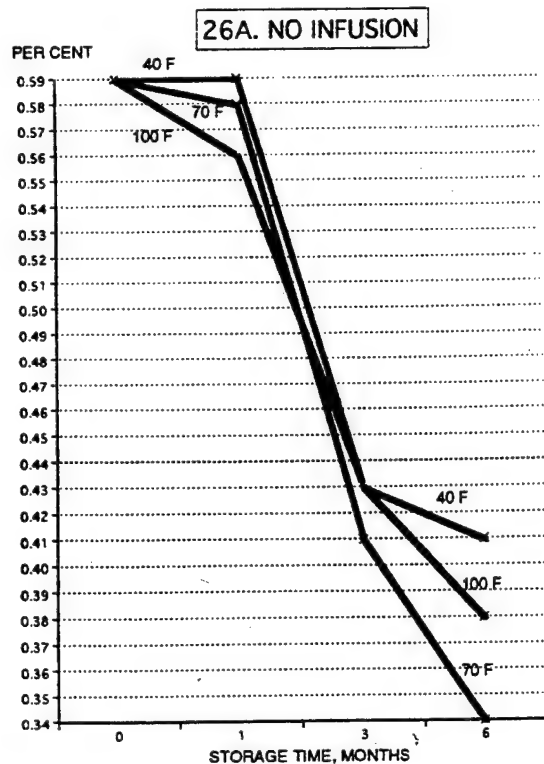


Fig. 26 - WATER ACTIVITY OF NUTRIENT ENHANCED CRANBERRIES

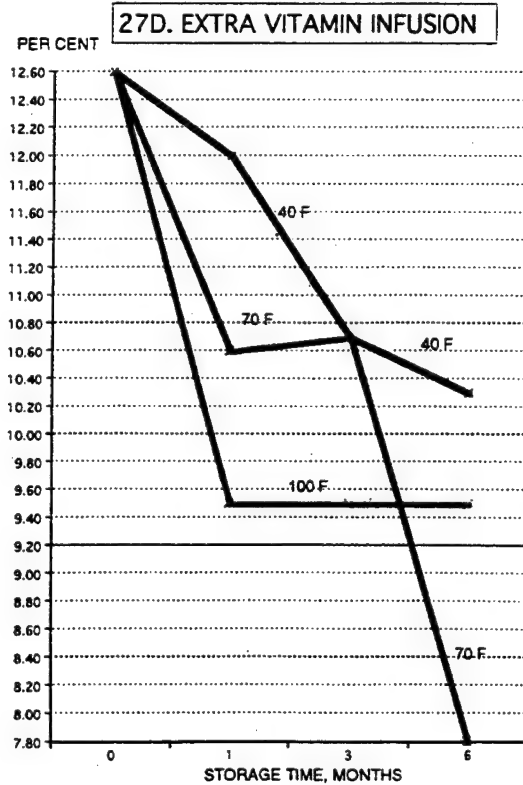
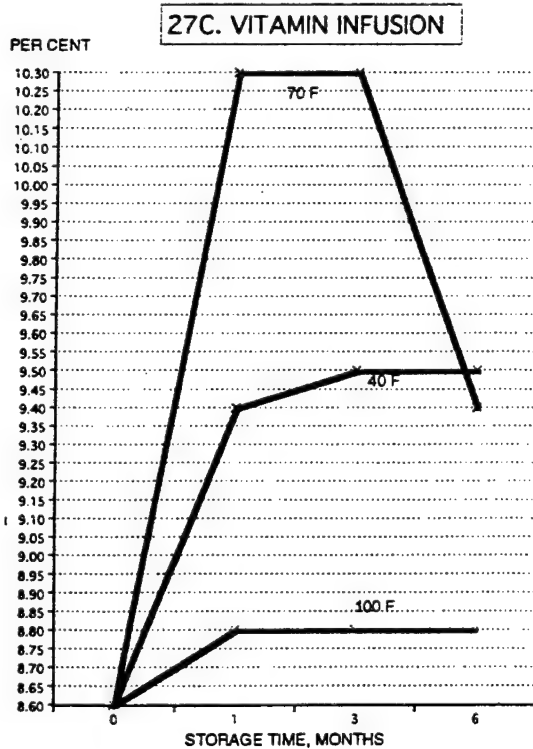
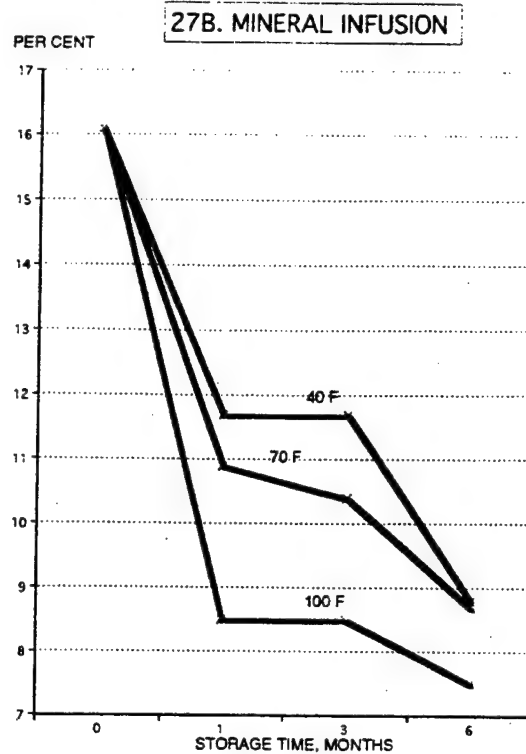
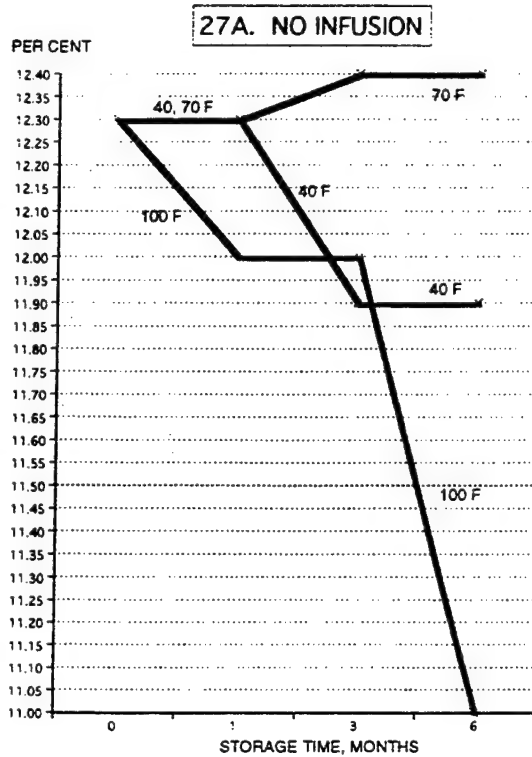


Fig. 27 - MOISTURE CONTENT OF NUTRIENT ENHANCED CRANBERRIES

## Reflectance

### L Values

Table 34 contains the reflectance L values. They are plotted in Figure 28.

**TABLE 34 - REFLECTANCE L VALUES OF NUTRIENT ENHANCED CRANBERRIES**

Added Nutrient	Storage Temp., °F	Storage Time, Months							
		0		1		3		6	
		actual	smooth	actual	smooth	actual	smooth	actual	smooth
minerals	40	14.8	14.8	17.7	14.8	12.5	12.5	13.0	12.5
minerals	70	14.8	14.8	21.4	18.2	18.2	18.2	19.3	18.2
minerals	100	14.8	14.8	22.1	18.9	18.9	18.9	20.4	18.9
vitamins*	40	18.6	18.6	20.8	18.6	15.7	17.1	17.1	15.7
vitamins*	70	18.6	18.6	22.0	18.6	18.0	18.6	20.3	18.0
vitamins*	100	18.6	18.6	21.7	18.6	18.7	18.7	20.5	20.5
vitamins	40	15.7	15.7	19.1	19.1	19.2	19.1	15.8	15.8
vitamins	70	15.7	15.7	21.9	19.0	19.0	19.0	19.6	19.0
vitamins	100	15.7	15.7	22.9	18.8	18.8	20.6	20.6	20.6
none	40	18.3	18.3	21.5	19.5	19.5	20.0	20.0	20.0
none	70	18.3	18.3	22.3	19.0	19.0	20.2	20.2	20.2
none	100	18.3	18.3	21.3	19.3	19.3	21.3	21.8	21.8

\* Greater amount of Vitamin B12

There were no significant differences attributed to any of the factors studied.

### a Values

Table 35 contains the reflectance a values. They are plotted in Figure 29

**TABLE 35 - REFLECTANCE a VALUES OF NUTRIENT ENHANCED CRANBERRIES**

Added Nutrient	Storage Temp., °F	Storage Time, Months							
		0		1		3		6	
		actual	smooth	actual	smooth	actual	smooth	actual	smooth
mineral	40	5.3	5.3	6.7	5.9	5.9	5.9	4.3	4.3
mineral	70	5.3	5.3	1.6	3.7	3.7	3.4	3.4	3.4
mineral	100	5.3	5.3	2.5	3.2	3.2	2.5	2.5	2.5
vitamin*	40	4.7	4.7	5.7	5.7	7.0	5.7	4.1	4.1
vitamin*	70	4.7	4.7	4.3	4.3	3.3	3.2	3.3	3.2
vitamin*	100	4.7	4.7	3.7	3.9	3.9	3.7	2.6	2.6
vitamin	40	7.7	7.7	3.9	5.7	5.7	5.0	5.0	5.0
vitamin	70	7.7	7.7	3.7	4.5	4.5	4.5	5.3	5.3
vitamin	100	7.7	7.7	4.0	4.0	4.0	4.0	2.6	2.6
none	40	4.2	4.2	3.8	4.2	4.4	4.4	5.1	5.1
none	70	4.2	4.2	3.1	4.1	4.1	4.1	4.6	4.6
none	100	4.2	4.2	2.4	3.2	3.2	2.9	2.9	2.9

\* Greater amount of Vitamin B12

There were no significant differences attributed to any of the factors studied.



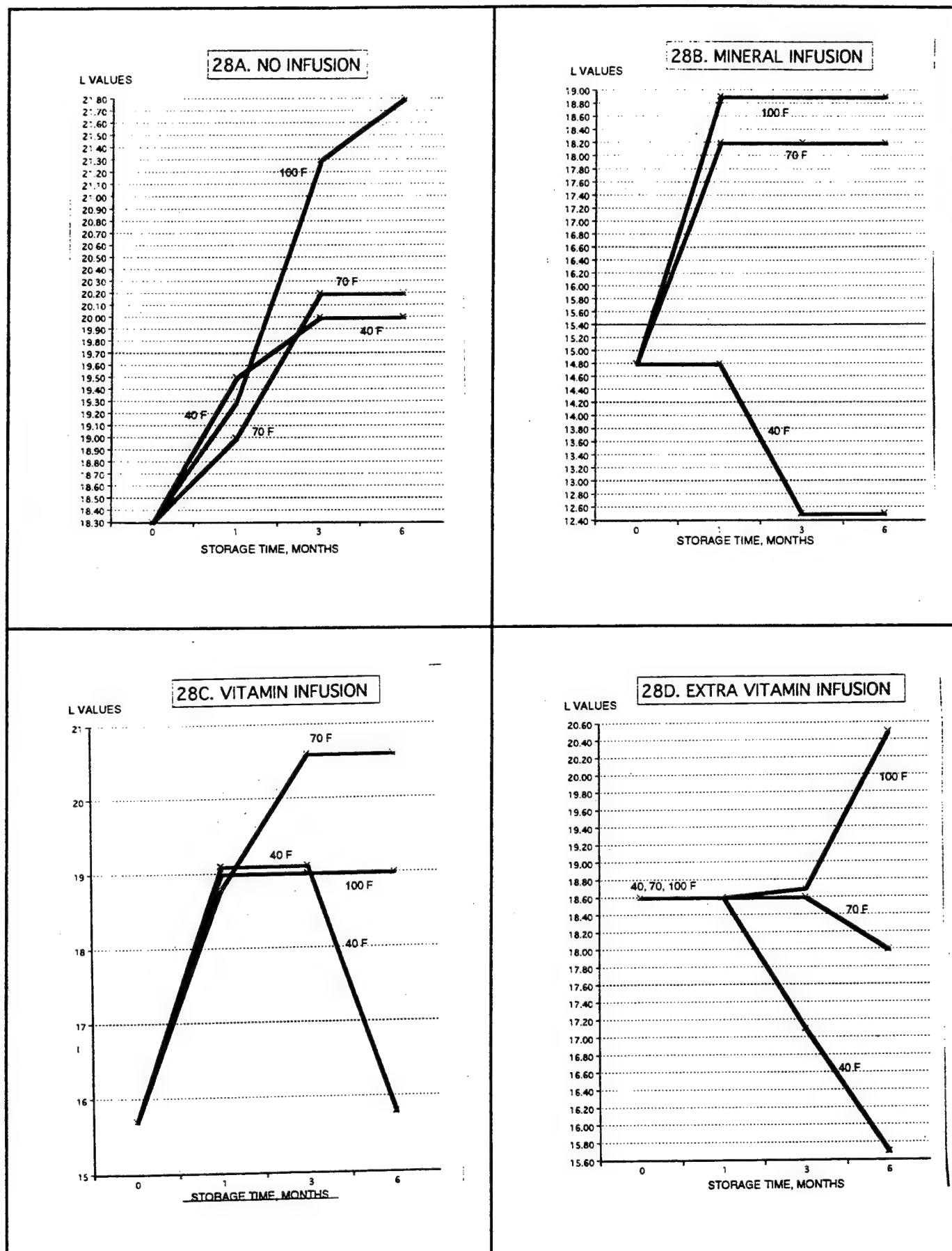


Fig. 28 - REFLECTANCE L VALUES OF NUTRIENT ENHANCED CRANBERRIES

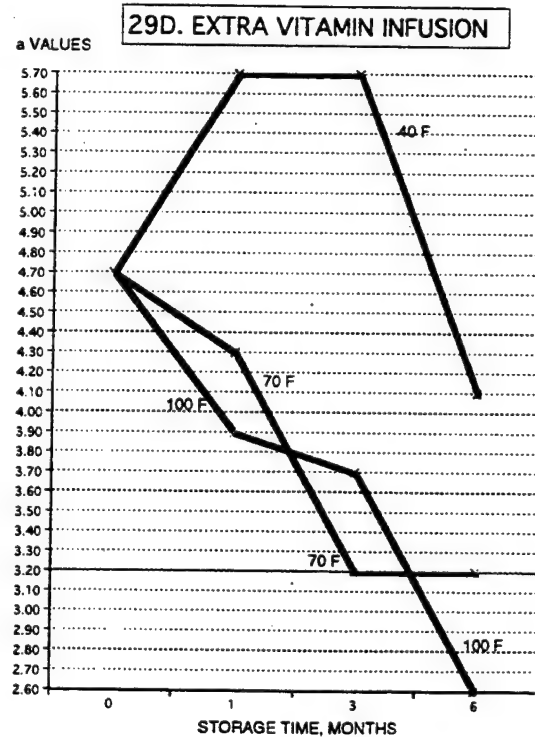
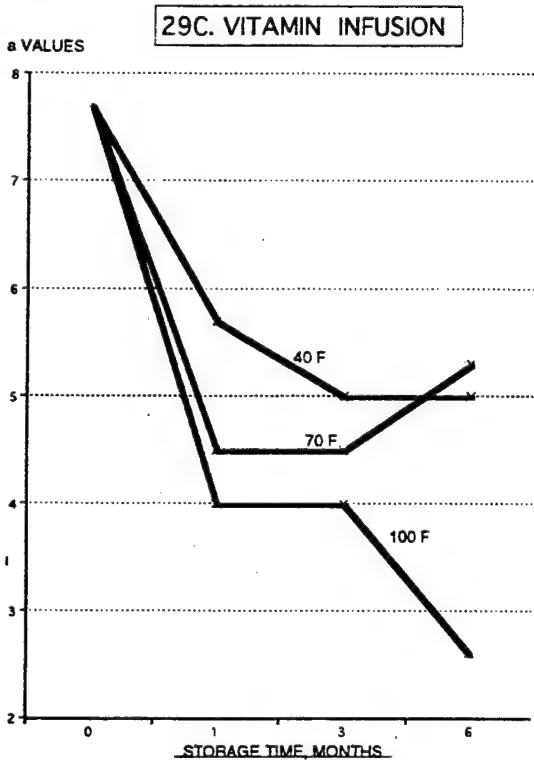
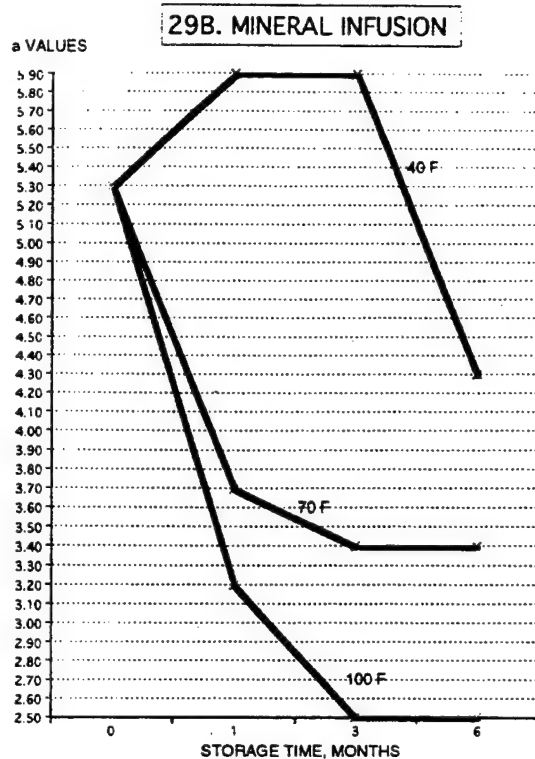
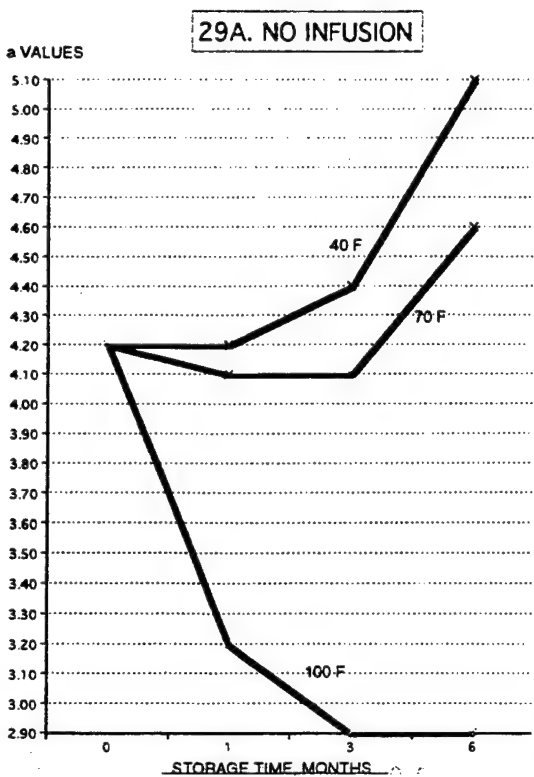


Fig. 29 - REFLECTANCE a VALUES OF NUTRIENT ENHANCED CRANBERRIES

# **b Values**

Table 36 contains the reflectance b values. They are plotted in Figure 30.

**TABLE 36 - REFLECTANCE b VALUES OF NUTRIENT ENHANCED CRANBERRIES**

<u>Added</u> <u>Nutrient</u>	<u>Storage</u> <u>Temp., °F</u>	<u>Storage Time, Months</u>							
		<u>0</u>		<u>1</u>		<u>3</u>		<u>6</u>	
		<u>actual</u>	<u>smooth</u>	<u>actual</u>	<u>smooth</u>	<u>actual</u>	<u>smooth</u>	<u>actual</u>	<u>smooth</u>
mineral	40	1.1	1.1	1.6	1.6	1.7	1.6	0.9	0.9
mineral	70	1.1	1.1	-0.3	0.6	0.6	0.6	0.9	0.6
mineral	100	1.1	1.1	0.4	1.1	1.7	0.8	0.8	0.8
vitamin*	40	0.7	0.7	0.9	0.9	1.4	0.9	0.5	0.5
vitamin*	70	0.7	0.7	0.4	0.4	0.1	0.4	0.4	0.4
vitamin*	100	0.7	0.7	0.4	0.7	1.4	0.5	0.5	0.5
vitamin	40	1.8	1.8	0.4	0.8	0.8	0.8	0.8	0.8
vitamin	70	1.8	1.8	0.3	0.6	0.6	0.6	1.0	0.6
vitamin	100	1.8	1.8	0.8	0.8	0.8	0.8	0.4	0.4
none	40	0.6	0.6	0.4	0.5	0.5	0.5	0.9	0.9
none	70	0.6	0.6	0.3	0.5	0.5	0.5	0.8	0.8
none	100	0.6	0.6	0.4	0.5	0.5	0.5	1.0	1.0

\* Greater amount of Vitamin B<sub>12</sub>.

There were no significant differences due to any of the factors studied.

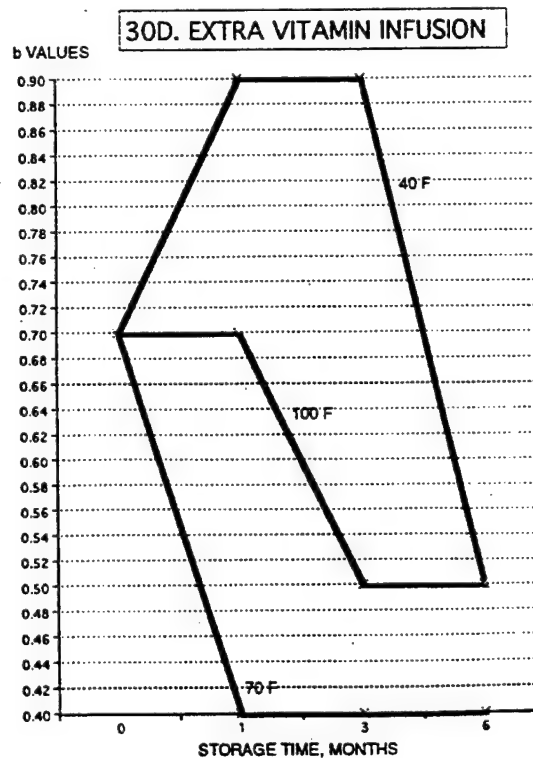
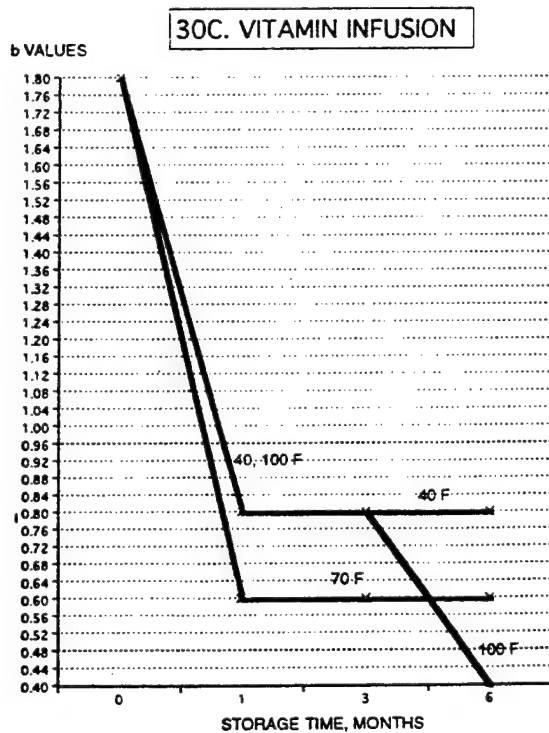
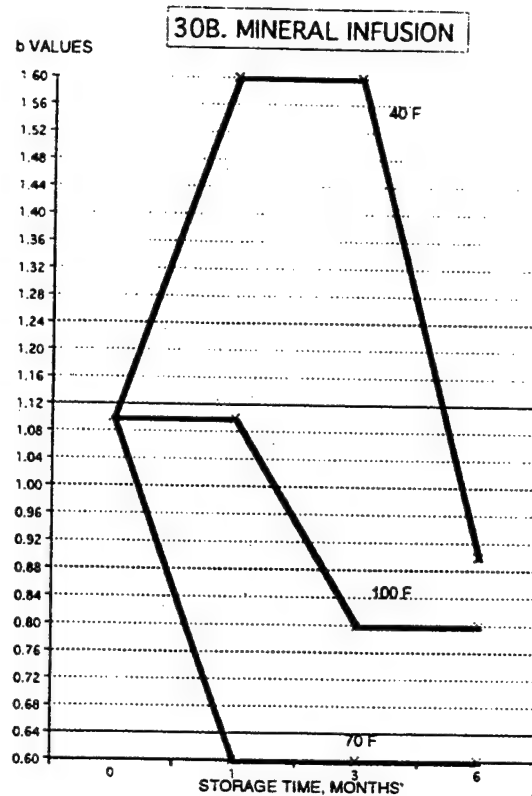
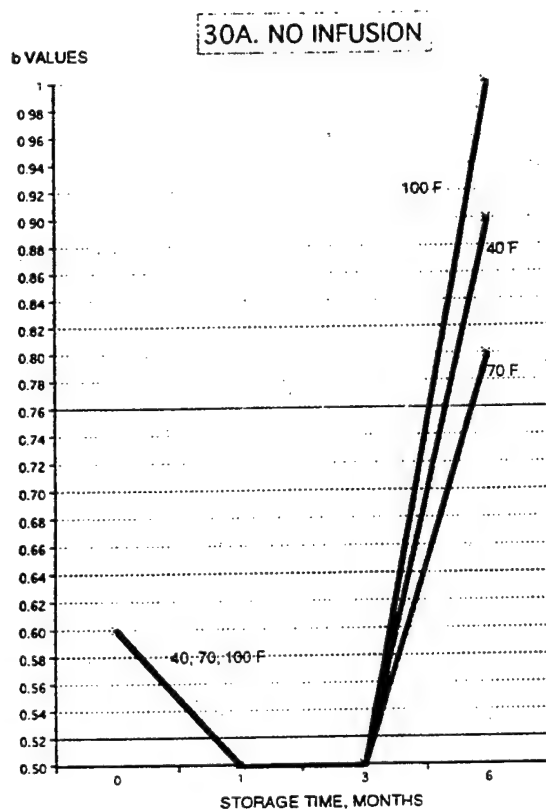


Fig. 30 - REFLECTANCE b VALUES OF NUTRIENT ENHANCED CRANBERRIES

## Data Analysis

The data analysis for all the physical data is contained in Table 37.

**TABLE 37 - DATA ANALYSIS FOR NUTRIENT ENHANCED CRANBERRIES**

### A. Analysis of Variance

Factor	<u>Aw</u>		<u>% Moisture</u>		<u>L</u>		<u>a</u>		<u>b</u>	
	<i>F</i>	<i>Sign.</i>	<i>F</i>	<i>Sign.</i>	<i>F</i>	<i>Sign.</i>	<i>F</i>	<i>Sign.</i>	<i>F</i>	<i>Sign.</i>
Time	8.10	0.01	0.09	nsd	0.13	nsd	0.13	nsd	0.12	nsd
Temperature	0.04	nsd	0.18	nsd	0.44	nsd	1.51	nsd	0.70	nsd
Nutrient	0.00	nsd	0.06	nsd	0.90	nsd	0.19	nsd	1.23	nsd
Time x Temp.	0.07	nsd	0.01	nsd	0.37	nsd	0.09	nsd	0.36	nsd
Time x Nutrient	1.12	nsd	0.00	nsd	0.74	nsd	0.31	nsd	0.02	nsd
Temp. x Nutrient	0.14	nsd	0.00	nsd	0.35	nsd	0.19	nsd	0.14	nsd
Time x Temp. x Nutrient	0.68	nsd	0.00	nsd	0.32	nsd	0.03	nsd	0.30	nsd

### B. Correlation

<u>Factors</u>	<u>Correlation</u>	<u>Significance</u>
Aw x Percent Moisture	0.73	0.01
Aw x L	0.05	nsd
Aw x a	0.04	nsd
Aw x b	0.45	0.01
Percent Moisture x L	0.07	nsd
Percent Moisture x a	0.06	nsd
Percent Moisture x b	0.36	0.05
L x a	0.64	0.01
L x b	0.50	0.01
a x b	0.85	0.01

The mean standard deviation for all L values was 0.89 with a range of 0.33 to 1.52. The mean standard deviation for all a values was 0.88 with a range of 0.20 to 2.43. The mean standard deviation for all b values was 0.34 with a range of 0.06 to 0.66. Since the standard deviation is so high it casts a doubt on the accuracy of the reflectance readings.

This was further indicated by an experiment in which four reflectance measurements were made on exactly the same surface of a cranberry sample. This was repeated on the reverse side of the sample cell. The four identical L readings yielded values of 17.37 and 17.67 with standard deviations of 0.25 and 0.04. The four identical a readings yielded values of 2.49 and 3.15 with standard deviations of 0.09 and 0.20. The four identical b values yielded values of 0.32 and 0.79 with standard deviations of 0.18 and 0.10.

The moisture content and water activity are closely related. The water activity; and moisture content directly affect the b values. The reflectance values are all related to each other.

# Sensory Testing

## Consumer Panel

The consumer panel scores for both initial testing without storage and after 1 month storage at 120 °F are contained in Table 38.

**TABLE 38 - CONSUMER PANEL SCORES FOR NUTRIENT ENHANCED CRANBERRIES**

Score	Storage Conditions					
	No Storage Time			1 Month Storage at 120 °F		
	Added Nutrient					
	Vitamins	Minerals	None	Vitamins	Minerals	None
	Number of Scores					
<u>A. Overall Acceptability</u>						
9	0	1	2	2	1	3
8	7	3	11	7	5	5
7	12	10	10	8	5	12
6	11	9	7	5	10	6
5	1	4	2	10	5	4
4	3	6	2	1	4	4
3	4	1	3	1	2	1
2	0	2	0	1	3	1
1	0	2	1	1	1	0
N	38	38	38	36	36	36
Mean	6.2	5.5	6.5	6.1	5.5	6.3
SD	1.5	2.0	1.8	1.8	2.0	1.7
<u>B. Flavor</u>						
9	1	0	0	4	2	4
8	8	5	12	6	5	5
7	10	9	10	7	7	10
6	9	10	7	9	9	7
5	3	4	3	6	2	3
4	4	4	2	2	4	4
3	3	2	3	0	4	1
2	0	2	0	1	2	1
1	0	2	1	1	1	1
N	38	38	38	36	36	36
Mean	6.2	5.6	6.3	6.3	5.7	6.3
SD	1.6	2.0	1.8	1.8	2.1	2.0

(Continued)

TABLE 38 - CONSUMER PANEL SCORES FOR NUTRIENT INFUSED CRANBERRIES

(Continued)

C. Color

9	1	0	1	1	0	5
8	5	5	13	11	2	6
7	14	8	10	2	10	7
6	11	12	6	7	8	10
5	2	4	6	11	6	6
4	4	4	0	2	4	2
3	0	3	1	2	3	0
2	1	1	0	0	2	0
1	0	1	1	0	1	0
N	38	38	38	36	36	36
Mean	6.3	5.7	6.7	6.2	5.4	6.7
SD	1.4	1.7	1.6	1.6	1.8	1.5

D. Texture

9	0	1	1	1	1	4
8	7	4	12	6	3	9
7	12	12	10	8	9	11
6	8	6	8	9	6	8
5	1	5	3	6	5	2
4	7	5	3	4	7	2
3	3	4	0	1	2	0
2	0	1	0	0	2	0
1	0	0	1	1	1	0
N	38	38	38	36	36	36
Mean	6.1	5.8	6.6	6.0	5.4	7.0
SD	1.6	1.7	1.6	1.7	1.9	1.3

The data analysis for the consumer panel scores are contained in Table 39.

TABLE 39 - DATA ANALYSIS OF CONSUMER PANEL SCORES FOR NUTRIENT ENHANCED CRANBERRIES

Factor	Characteristic							
	Overall		Flavor		Color		Texture	
	<u>F</u>	<u>Sign.</u>	<u>F</u>	<u>Sign.</u>	<u>F</u>	<u>Sign.</u>	<u>F</u>	<u>Sign.</u>
Time	0.08	nsd	0.01	nsd	0.03	nsd	0.32	nsd
Nutrient	0.47	nsd	0.06	nsd	0.69	nsd	2.02	nsd
Time x Nutrient	0.01	nsd	0.07	nsd	0.11	nsd	0.49	nsd

Although there was no significant difference due to any factor, the mineral infused cranberries had lower ratings for all characteristics, than the vitamin infused cranberries.

### Technical Panel

The technical panel scores are contained in Table 40.

**TABLE 40 - TECHNICAL PANEL SCORES OF NUTRIENT ENHANCED CRANBERRIES**

	Characteristic									
	Overall		Odor		Flavor		Texture		Appearance	
	Storage Time, months									
	0	1	0	1	0	1	0	1	0	1
<b><u>A. Vitamins</u></b>										
N	10	14	10	14	10	14	10	14	10	14
Mean	6.4	6.1	6.7	5.9	6.5	6.3	6.4	6.4	6.4	5.7
SD	1.0	1.0	0.5	1.2	1.0	1.0	1.0	0.8	1.0	1.1
<b><u>B. Minerals</u></b>										
N	10	14	10	14	10	14	10	14	10	14
Mean	6.2	5.9	6.7	4.9	6.2	4.6	6.2	5.0	6.4	4.4
SD	0.8	1.5	0.5	1.4	0.8	1.2	0.6	1.4	0.7	0.9
<b><u>C. None</u></b>										
N	10	14	10	14	10	14	10	14	10	14
Mean	6.6	6.9	6.7	6.8	6.4	7.1	6.9	6.8	6.5	7.2
SD	0.8	0.9	0.5	0.6	1.0	0.6	0.6	0.9	0.7	0.7

The data analysis for the technical panel scores are contained in Table 41.

**TABLE 41 - DATA ANALYSIS FOR TECHNICAL PANEL SCORES FOR NUTRIENT ENHANCED CRANBERRIES**

Factor	Characteristic									
	Overall		Odor		Flavor		Texture		Appearance	
	F	Sign.	F	Sign.	F	Sign.	F	Sign.	F	Sign.
Time	0.22	nsd	0.93	nsd	0.03	nsd	1.34	nsd	0.00	nsd
Nutrient	0.13	nsd	0.00	nsd	0.04	nsd	1.00	nsd	0.04	nsd
Time x Nutrient	0.87	nsd	2.33	nsd	1.61	nsd	0.01	nsd	4.26	0.05

Although the only factor that showed significance was the affect of the interaction of time and nutrient addition on the overall acceptability, there was a general lowering of scores for both the vitamin and mineral enriched cranberries with storage. This was not shown with the non-nutrient enriched cranberries which actually showed an increase in some factors with storage.

Although the scores showed no differences initially, the mineral enriched cranberries rated lower than the vitamin enriched cranberries which were lower than the non-nutrient enriched cranberries after one month of storage.

However, all these observations were not significant. The number of panelists is not large enough to show significance for this type of test.



### Field Test

The field test was conducted at Ft. Lewis, Washington Army Base.

The results are contained in Table 42.

**Table 42 - FIELD TEST RESULTS OF NUTRIENT ENHANCED CRANBERRIES**

	<u>Nutrient</u>	
	<u>Vitamin</u>	<u>Mineral</u>
Number of Panelists	54	73
Mean	7.2	6.8
SD	2.3	2.5

The scores were highly acceptable. There was no difference between the two types of nutrient enrichment. ( $t = 0.42$ )

The nutrient infused cranberries are acceptable for inclusion in the MRE.

### Nutrient Content

The initial mineral content of the cranberries are contained in Table 43. It has been corrected to 100% dryness.

**TABLE 43 - MINERAL CONTENT OF NUTRIENT ENHANCED CRANBERRIES**

<u>Nutrient</u>	<u>ppm</u>
Ca	810
Mg	500
Zn	21

The folic acid could not be measured because of interfering substances. The Vitamin B12 content although detectable was too low to be quantified.

### PRELIMINARY FRUIT STUDY

Some large pieces of fruit had been prepared on a bench-top scale as a preliminary study. This was reported in a technical report by Cohen and Yang (1995). These products were stored in large glass jars in direct sunlight for three years. Observation of the fruits showed no visible evidence of spoilage at that time. This is an indication that fruit prepared with osmotic dehydration at a low water activity can keep for an almost indefinite period without visible bacterial growth. Table 44 contains the initial moisture and water activity of the fruit.

**TABLE 44 - INITIAL MOISTURE AND WATER ACTIVITY OF FRUIT**

<u>Fruit</u>	<u>Percent Moisture</u>	<u>Water Activity</u>
Cherries	37	0.60
Cherries	17	0.56 *
Peaches	33	0.81
Nectarines	25	0.78
Apples	17	0.68
Apples	30	0.67

## **SPECIFICATION**

The final results of all these studies culminated in a military commercial item description (CID) to purchase various fruits with various infused nutrients. That specification is given in the Appendix.

## REFERENCES

- AOAC, 1995. Official Methods of Analysis. Moisture, Chapter 37. Fruits and Fruit Products
- Cohen, Joseph and Yang, Tom C.S., Sept. 1995. Osmotic Dehydration and Its Applicationa in Nutrient Infusion of Various Foods. Technical Report, US Army, Soldier Systems Command, Natick Research, Development and Engineering Center, TR-95/034
- Cohen, Joseph, Yang, Tom C.S. and Atwood, Bonita, Apr. 1997. Storage Stability of Six Osmotically Dried Commercial Fruit Products. Technical Report, US Army, Soldier Systems Command, Natick Research, Development and Engineering Center, TR-97/01
- Cohen, Joseph and Tucker, Jeff., May 1998. Nutrient Enhancement of Fruit and Effects of Storage Conditions. Technical Report, US Army, Soldier Systems Command, Natick Research, Development and Engineering Center, TR-98/023
- Fito, P., Andres, A., Pastor, R and Chiralt, A., 1994\*, Vacuum Osmotic Dehydration of Fruits.
- Lazarides, Andrzej, 1994\*, Osmotic Dehydration of Fruits Befored Drying
- Lenart, Harris N., 1994\*, Osmotic Preconcentration; Developments and Prospects
- Rader, Jeanne I., Weaver, Carol M. and Angyal, Gerald., 1999. Advances in the analysis of folates in foods. Food Testing and Analysis, Vol.5 (2), April/May 1999, 14-32
- \* Chapters in Minimal Processing of Foods and Process Optimization, An Interface, 1994, Singh, R. Paul and Oliveira, Fernanda A.R. CRC Press

This document reports research undertaken at the U.S. Army Soldier and Biological Chemical Command, Soldier Systems Center, and has been assigned No. NATICK/TR-99034 in a series of reports approved for publication.



## Appendix - Commercial Item Description Fruits, Osmotically Dried

## APPENDIX

METRIC  
A - A - 20299  
AUGUST 31, 1998

### COMMERCIAL ITEM DESCRIPTION

#### FRUITS, OSMOTICALLY DRIED

The U.S. Department of Agriculture has authorized  
the use of this Commercial Item Description.

#### 1. SCOPE.

1.1 This Commercial Item Description (CID) covers osmotically dried fruits, packed in commercially acceptable containers, suitable for use by Federal, State, local governments and other interested parties and as a component of operational rations.

#### 2. CLASSIFICATION.

2.1 The osmotically dried fruits shall conform to the type(s), style(s), flavor(s), and fortification(s) for the osmotically dried fruits and shall be of the following, as specified in the solicitation, contract, or purchase order.

##### Types, styles, flavors, and fortification(s).

Type I - Pitted red tart cherries

Style A - Whole

Style B - Other

---

Beneficial comments, recommendations, additions, deletions, clarifications, etc., and any data which may improve this document should be sent to: Head, Food Quality Assurance Staff, Fruit and Vegetable Programs, Agricultural Marketing Service, U.S. Department of Agriculture, STOP 0243, 1400 Independence Ave., SW, Washington, DC 20250-0243 or telephone (202) 720-9939 or FAX (202) 690-0102

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**Type II - Pitted sweet cherries**

**Style A - Whole**

**Style B - Other**

**Type III - Flavored apple cubes**

**Flavor 1 - Passion fruit/cherry**

**Flavor 2 - Cherry/cinnamon**

**Flavor 3 - Mango**

**Flavor 4 - Other**

**Type IV - Whole strawberries**

**Type V - Sliced bananas**

**Type VI - Whole blueberries**

**Type VII - Whole cranberries**

**Type VIII - Other**

**Fortification**

**Fortification a - Not fortified**

**Fortification b - Fortified with magnesium**

**Fortification c - Fortified with zinc**

**Fortification d - Fortified with folic acid**

**Fortification e - Other**

**3. SALIENT CHARACTERISTICS**

**3.1 Raw ingredients:** The frozen red tart cherries shall be prepared from U.S. Grade B or better for the U.S. Standards for Grades of Frozen Red Tart Pitted Cherries. The frozen sweet cherries shall be prepared from U.S. Grade Commercial or better for the U.S. Standards for Grades for Sweet Cherries. The frozen blueberries, cranberries and strawberries shall be U.S. Grade No. 1 for the appropriate frozen berries, except that strawberries shall be calyx free. The frozen apples shall be prepared from U.S. Grade No. 1 or better for the U.S. Standards for Grades of Apples for processing.

**3.2 Processing:** The osmotically dried fruits shall be manufactured in accordance with good manufacturing practices. Osmosis is the passage of a fluid (such as sugar water) through a semipermeable membrane into a solution where its concentration is lower, thus equalizing the conditions on both sides of the membrane.

**3.2.1 Osmotic drying:** The osmotically dried fruits may be infused with sugar or other sweeteners as appropriate for the type of fruit. Flavors (including acids) may be used as appropriate.

**3.2.2 Fortification:** The fortification and levels of fortification shall be as specified in the solicitation, contract, or purchase order.

**3.3 Finished product:** Prior to packing, the osmotically dried fruits may be sprayed lightly with sunflower oil or other vegetable oil to prevent clumping.

**3.3.1 Appearance:** The appearance of the osmotically dried fruits shall be as follows: The pitted red tart and sweet cherries, blueberries, cranberries and strawberries are intact pieces of fruit which may be irregularly shaped. The diced apples shall be small cubes and the bananas shall be small slices.

**3.3.2 Flavor and odor:** The osmotically dried fruits shall have a distinct, characteristic flavor and odor of the appropriate Type and Flavor of osmotically dried fruit. There shall be no foreign odors or flavors, such as, but not limited to, stale, rancid or moldy.

**3.3.3 Color:** The osmotically dried cherries shall have a uniform characteristic bright red to dark red cherry color. The osmotically dried apple cubes shall have a uniform color appropriate to the flavoring added to the apples. The osmotically dried blueberries, strawberries, bananas, and cranberries shall have a uniform color characteristic of the fruit.

**3.3.4 Texture:** The osmotically dried fruit shall have a soft or chewy texture as appropriate for the type of fruit.

**3.4 Foreign material:** The osmotically dried fruits shall be clean, sound, wholesome, and free from evidence of rodent or insect infestation. The osmotically dried fruits shall be free from foreign material such as, but not limited to, dirt, insect parts, hair, wood, glass or metal.

**3.5 Additives or preservatives:** No additives, preservatives, or flavors, other than sweeteners and fortification when applicable, may be used in the processing of the product.

**3.6 Analytical and microbiological requirements:** Unless otherwise specified in the solicitation, contract, or purchase order, the analytical and microbiological requirements for osmotically dried fruits shall be as stated:

**3.6.1 Water Activity:** The water activity ( $a_w$ ) for the osmotically dried fruits shall not exceed 0.620.



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3.6.2 **Added oil:** The added oil for the osmotically dried fruits shall be between 0.1 and 1.0 percent.

3.6.3 **pH:** The pH for red tart and sweet cherries shall be between 3.4 and 4.0; for strawberries, blueberries, and cranberries between 3.2 and 3.8; for bananas between 4.0 and 4.2

3.6.4 **Total standard plate count:** The total standard plate count for the osmotically dried fruits, shall not exceed 500 per gram.

3.6.5 **Total coliforms:** The total coliforms for the osmotically dried fruits, shall not exceed 10 per gram.

3.6.6 **E.coli:** The *E. coli* for the osmotically dried fruits shall not exceed 3 per gram.

3.6.7 **Staph. aureus:** The staph. aureus (coagulase positive) for the osmotically dried fruits shall not exceed 10 per gram.

3.6.8 **Yeast and mold:** The yeast and mold (combined) for the osmotically dried fruits shall not exceed 100 per gram.

3.6.9 **Analytical sample procedure:** Use Processed Products Branch (PPB) sampling procedures.

3.6.10 **Analytical and microbiological testing:** Analytical and microbiological testing shall be in accordance with the following method from the Official Methods of Analysis of the AOAC International (16th Edition):

<b><u>Test</u></b>	<b><u>Method</u></b>
<i>a<sub>w</sub></i>	978.18
Standard Plate Count	980.31
pH	981.12
Yeast and Mold	995.21
Coliform	992.30
<i>E. coli</i>	996.09
Staph. aureus	987.09
Oil	1/

1/ Conduct test in accordance with U.S. Department of Agriculture, Agricultural Marketing Service, Science and Technology Program, Midwestern Laboratory Method No. 74 "oil Analysis of Dried Cherries."

3.6.11 **Test results:** The test results for  $a_w$  shall be reported to the nearest 0.001. The test results for oil shall be reported to the nearest 0.1 percent. The total standard plate count shall be reported to the nearest 10 per gram. The test results for yeast and mold shall be reported to the nearest 50 per gram. The test results for coliform shall be reported to the nearest 10 per gram. The test results for *E. coli* shall be reported to the nearest 1 per gram. Any results not conforming to the finished product requirements shall be cause for rejection of the lot.

#### 4. REGULATORY REQUIREMENTS.

4.1 The delivered osmotically dried fruits shall comply with all applicable Federal, State, and local mandatory requirements and regulation relating to the preparation, packaging and labeling, storage, distribution and sale of the osmotically dried fruits in the commercial marketplace. Delivered osmotically dried fruits shall conform in every respect to the provisions of the Federal Food, Drug, and Cosmetic Act and regulations promulgated thereunder.

#### 5. QUALITY ASSURANCE PROVISIONS.

5.1 **Product conformance.** The osmotically dried fruits provided shall meet the salient characteristics of this CID, conform to the producer's own specifications, standards, and quality assurance practices, and be the same osmotically dried fruits offered for sale in the commercial market. The Government reserves the right to require proof of such conformance.

5.2 **Quality assurance:** When required in the solicitation, contract, or purchase order that product quality or acceptability or both be determined the Processed Products Branch (PPB), Fruit and Vegetable Programs, Agricultural Marketing Service, U.S. Department of Agriculture shall be the certifying activity and shall make the determination in accordance with applicable PPB procedures. The osmotically dried fruits shall be examined or analyzed or both in accordance with applicable provisions in the CID, solicitation, contract, or purchase order, and when applicable, the United States Standards for Condition of Food Containers in effect on the date of solicitation.

#### 6. PACKAGING.

6.1 **Preservation, packaging, packing, labeling, and case marking.** Preservation, packaging, packing, labeling, and case marking shall be as specified in the solicitation, contract, or purchase order.

## 7. NOTES

### 7.1 Purchasers shall specify:

- Type(s), style(s), flavor(s), and forification.
- When analytical testing is not required.
- When  $a_w$  is different than specified in the CID.

### 7.2 Sources if documents.

#### 7.2.1 Source of information for nongovernmental document is as follows:

Copies of the Official Methods of Analysis of the AOAC International may be obtained from: AOAC International, 481 North Frederick Avenue, Suite 500, Gaithersburg, MD 20877.

#### 7.2.2 Sources of information for governmental documents are as follows:

Applicable provisions of the Federal Food, Drug, and Cosmetic Act are contained in 21 CFR Parts 1 to 199. This document may be purchased from: **Superintendent of Documents, ATTN: New Orders, P.O. Box 371954, Pittsburgh, PA 152507954.** Credit card (MasterCard or Visa) purchases may be made by calling the Superintendent of Documents on (202) 512-1803 or on the Internet at: <http://www.nara.gov/fedreg>.

Copies of the United States Standards for Grades of Red Tart Pitted Cherries, Canned, are available from: **Chief, Processed Products Branch, Fruit and Vegetable Program, Agricultural Marketing Service, U.S. Department of Agriculture, STOP 0247, 1400 Independence Avenue, Washington, 20250-0247.**

Copies of the United States Standards for Grades of Apples, Blueberries, Sweet Cherries, Fresh Cranberries, and Strawberries are available from: **Chief Fresh Products Branch, Fruit and Vegetable Program, Agricultural Marketing Service, U.S. Department of Agriculture, STOP 0240m 1400 Independence Avenue, Washington, DC 20250-0240.**

Copies of the United States Standards for Condition of Food Containers are available from: **Chairperson, Condition of Container Committee, U.S. Department of Agriculture, STOP 0243, 1400 Independence Avenue, SW, Washington, DC 20250-0243.**

Civil agencies and other interested parties may obtain copies of this CID from: **General Services Administration, Federal Supply Service, Specifications Section, Suite 8100, 470 East L'Enfant Plaza, SW, Washington, DC 20407**

Military activities should submit requests for copies of this CIS to: **Standardization Documents Order Desk, Defense Automation Printing Service, 700 Robbins venue, Building 4D, Philadelphia, PA 19111-5094**

**MILITARY INTERESTS;**

**CIVIL AGENCY COORDINATING ACTIVITIES:**

**Military Coordinating Activity:**

Army - GL

DOJ - BOP  
HHS - NIH, IHS  
VA - OSS

**Custodians**

Army - GL  
Navy - SA  
ir force - 35

**PREPARING ACTIVITY:**

USDA - FV

**Review Activities**

Army - MD, QM  
Navy - MC  
DLA - S

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QUALITY ASSURANCE PROVISIONS AND PACKAGING REQUIREMENTS FOR CID A-A-20299,  
FRUITS, OSMOTICALLY DRIED

SECTION C

C-1 ITEM DESCRIPTION

Types.

- Type I, Style A, Fortification d
- Type III, Flavor 3, Fortification b and c
- Type III, Flavor 3, Fortification d

Unless otherwise specified, the following applies to all types:

Each component is consumed by combat personnel under worldwide environmental extremes as part of an operational ration, and is a source of nutritional intake. It is essential that this item be produced in accordance with good commercial practice to attain high standards of appearance, odor, flavor, and texture so that high levels of troop acceptance are achieved.

C-2 PERFORMANCE REQUIREMENTS

A. Production standard. A sample shall be subjected to first article or product demonstration model inspection, as applicable in accordance with the tests and inspections of Section E of this Quality Assurance Provisions and Packaging Requirements.

B. Net weight. The net weight of one serving of Type I and Type III product shall be 2 ounces.

C. Nutrient content. The nutrient content of the packaged food shall be as follows:

<u>Type</u>	<u>Magnesium 1/</u>	<u>Zinc 1/</u>	<u>Folic acid 1/</u>	<u>Calories 1/</u>
Type I, Style A	-	-	<300 mcg >400 mcg	<135
Type III, Flavor 3	< 225 mg > 325 mg	< 8.0 mg >12.0 mg	-	<135
Type III, Flavor 3	-	-	<300 mcg >400 mcg	<135

- 1/ < denotes not less than  
> denotes not greater than

QUALITY ASSURANCE PROVISIONS AND PACKAGING REQUIREMENTS FOR CID A-A-20299,  
FRUITS, OSMOTICALLY DRIED

SECTION D

D-1 PACKAGING

A, Packaging. One commercially wrapped and labeled package of osmotically dried fruit shall be packed in a preformed or form-fill seal barrier pouch as described below.

(1) Preformed pouches.

a. Pouch material. The preformed pouches shall be fabricated from 0.002 inch thick ionomer or polyethylene film laminated or extrusion coated to 0.00035 inch thick aluminum foil which is then laminated to 0.0005 inch thick polyester. The three plies shall be laminated with the polyester on the exterior of the pouch. All tolerances for thickness of pouch materials shall be plus or minus 20 percent. The pouch color shall conform to number 20219, 30219, 30227, 30279, 30313, 30324, or 30450 of FED-STD-595, Colors for Government Procurements. The material shall show no evidence of delamination, degradation, or foreign odor when heat-sealed or fabricated into pouches. The material shall be suitable formulated for food packaging and shall not impart an odor or flavor to the product.

b. Pouch construction. The pouch shall be a flat style preformed pouch having maximum inside dimensions of 4 inches wide by 7 inches long ( $\pm 1/8$  inch in each dimension). The pouch shall be made by heat sealing three edges with  $3/8$  inch ( $-1/18$  inch,  $+3/16$  inch) wide seals. The heat seals shall be made in a manner that will assure hermetic seals. The side and bottom seals shall have an average seal strength of not less than 6 pounds per inch of width and no individual specimen shall have a seal strength of less than 5 pounds per inch of width when tested as specified in E-5,A., (3), a. Alternatively, the filled and sealed pouch shall exhibit no rupture or seal separation greater than  $1/16$  inch or seal separation that reduces the effective closure seal width to less than  $1/16$  inch when tested for internal pressure resistance as specified in E-5,A., (3),c. A tear nick or tear notch shall be made in one or both side seals to facilitate easy opening of the filled and sealed pouch. A  $1/8$  inch ( $\pm 1/16$  inch) wide lip may be incorporated at the open end of the pouch to facilitate opening and filling of the pouch.

c. Pouch filling and sealing. One commercially wrapped and labeled package of osmotically dried fruit shall be inserted into the pouch. The filled pouch shall be sealed. The closure seal shall be free of foldover wrinkle or entrapped matter that reduces the effective closure seal width to less than  $1/16$  inch. Seals shall be free of impression or design on the seal surface that would conceal or impair visual detection of seal defects. The average seal strength shall be not less than 6 pounds per inch of width and no individual specimen shall have a seal strength of less than 5 pounds per inch of width when tested as specified in E-5,A., (3),b. Alternatively, the filled and sealed pouch shall exhibit no rupture or seal separation greater than  $1/16$  inch or seal separation that reduces the effective closure seal width to less than  $1/16$  inch when tested for internal pressure resistance as specified in - 5,A., (3), c.

QUALITY ASSURANCE PROVISIONS AND PACKAGING REQUIREMENTS FOR CID A-A-20299,  
FRUITS, OSMOTICALLY DRIED

SECTION D CONTINUED

(2) Horizontal form-fill-seal pouches.

a. Pouch material. The horizontal form-fill-seal pouch shall consist of a formed tray-shaped body with a flat sheet, heat sealable cover or a tray-shaped body with a tray-shaped heat sealable cover. The tray-shaped body and the tray-shaped cover shall be fabricated from a 3-ply flexible laminate barrier material consisting of, from outside to inside, 0.0009 inch thick oriented polypropylene bonded to 0.0007 inch thick aluminum foil with 10 pounds per ream pigmented polyethylene or adhesive and bonding the opposite side of the aluminum foil to 0.003 inch thick ionomer or a blend of not less than 50 percent linear low density polyethylene and polyethylene. The linear low density polyethylene portion of the blend shall be the copolymer of ethylene and octene-1 having a melt index range of 0.8 to 1.2 g/10 minutes in accordance with ASTM D 1238. Flow Rates of Thermoplastics by Extrusion Plastometer and a density range of 0.918 to 0.922 g/cc in accordance with ASTM D 1505, Density of Plastics by Density Gradient Technique. Alternatively, 0.0005 inch thick polyester may be used in place of the oriented polypropylene as the outer layer of the laminate. The flat sheet cover shall be made of the same 3-ply laminate as specified for the tray shaped body except the aluminum foil thickness may be 0.00035 inch. All tolerances for thickness of pouch materials shall be plus or minus 20 percent. The color requirements of the exterior (oriented polypropylene or polyester side) of the laminate shall be as specified in D-1, A. (1) (a). The material shall show no evidence of delamination, degradation, or foreign odor when heat-sealed or fabricated into pouches. The material shall be suitably formulated for food packaging and shall not impart any odor or flavor to the product.

b. Pouch construction. The tray-shaped body and the tray-shaped cover shall be formed by drawing the flexible laminates material into an appropriately shaped cavity. The flat cover shall be in the form of a flat sheet of the barrier material taken from the roll stock. One unit of commercially wrapped and labeled package of osmotically dried fruits shall be placed into the tray-shaped body of the pouch. Pouch closure shall be effected by heat sealing together the cover and body along the entire pouch perimeter. The closure seal width shall be a minimum of 1/8 inch. The closure seal shall have an average seal strength of not less than 6 pounds per inch of width and no individual specimen shall have a seal strength of less than 5 pounds per inch of width when tested as specified in E-5, A., (3) b. Alternatively, the filled and sealed pouch shall exhibit no rupture of seal separation greater than 1/16 inch or seal separation that reduces the effective closure seal width to less than 1/16 inch when tested for internal pressure resistance as specified in E-5, A., (3) c. The maximum outside dimensions of the sealed pouch shall be 5-1/2 inches wide by 8-5/8 inches long. The closure seal width shall be a minimum of 1/8 inch. A tear nick, a tear notch, or serrations shall be provided on one outside edge or two opposite outside edges of the pouch to facilitate easy opening of the filled and sealed pouch. The sealed pouches shall not show any evidence of material degradation, aluminum stress cracking, delamination or

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foreign odor. Heat seals shall be free of occluded matter. Seals shall be free of impression or design on the seal surface that would conceal or impair visual detection of seal defects.

D-2 LABELING

A. Pouches. Each pouch shall be clearly printed or stamped, in a manner that does not damage the pouch, with permanent black ink or other, dark, contrasting color which is free of carcinogenic elements or ingredients. The information shall be located on the body of the pouch not closer than 1/16 inch to any seal. If a non-contact type printer is used, the information may be located anywhere on the pouch (in one complete print), except the closure seal area. The label shall contain the following information:

- (1) Product name (letters not less than 1/8 to 7/16 inch block letters)
- (2) Date 1/
- (3) Net Weight
- (4) Contractor's name and address

1/. Each pouch shall have the date of pack note by using a four digit code beginning with the final digit of the current year followed by the three digit Julian day code. For example, 17 ebruary, 1998 would be coded as 8048. The Julian day code shall represent the day the product was packaged into the pouch.

D-3 PACKING

A. Packing for shipment to rtion assembler. Not more than 40 pounds of pouched product shall be packed flat in layers in a fiberboard shipping container constructed in accordance with style RSC-L, class domestic, variety SW, grade 200 of ASTM D 5118, Standard Practice for Fabrication of iberboard Shipping Boxes, Standard Practice for Methods of Closing, Sealing, and Reinforcing Fiberboard Shipping Containers.

D-4 MARKING

A. Shipping containers. Shipping containers shall be marked in accordance with DPSC Form 3556, Marking Instructions for Shipping Cases, Sacks and Pallaetized/Containerized Loads of Perishable and Semiperishable Subsistence.



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SECTION E INSPECTION AND ACCEPTANCE

Definitions.

(1) Critical defect. A critical defect is a defect that judgment and experience indicate would result in hazardous or unsafe conditions for individuals using, maintaining, or depending on the item; or a defect that judgment and experience indicate is likely to prevent the performance of the major end item, i.e., the consumption of the ration.

(2) Major defect. A major defect is a defect, other than critical, that is likely to result in failure, or to reduce materially the usability of the unit of product for its intended purpose.

(3) Minor defect. A minor defect is a defect that is not likely to reduce materially the usability of the unit of product for its intended purpose, or is a departure from established standards having little bearing on the effective use or operation of the unit.

E-5 PACKAGING AND PACKING MATERIALS

Quality Assurance Provisions.

The following quality assurance criteria, utilizing ANSI/ASQC Z1.4-1993, Sampling Procedures and Tables for Inspection by Attributes, are required.

A. Packaging.

(1) Pouch material certification. Material listed below may be accepted on the basis of a contractor's certification of conformance to the indicated requirements. In addition, compliance to the requirements for inside pouch dimensions and dimensions of manufacturer's seals may be verified by certificate of conformance.

<u>Requirement</u>	<u>Requirement paragraph</u>	<u>Test Procedure</u>
Thickness of films for laminated material	D-1, A.1. (a) and D-1, A.2 (a)	As specified in L-P-378 1/ except that a machinists' micrometer may be used provided that its graduations and accuracy conform to the requirements of L-P-378
Aluminum foil thickness	D-1, A.1. (a) and D-1, A.2. (a)	As specified in ASTM B 479 2/
Laminated material identification and construction	D-1, A.1. (a) and D-1, A.2. (a)	Laboratory evaluation
Color of laminated Material	D-1, A.1. (a) and D-1, A.2. (a)	Visual evaluation

1/ FED L-P-378, Plastic Sheet and Strip, Thin Gauge, Polyolefin

2/ ASTM B 479, Specification for Annealed Aluminum Foil For Flexible Barrier Application

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(20 Filled and sealed pouch examination. The filled and sealed pouches shall be examined for the defects listed in table I. The lot size shall be expressed in pouches. The sample unit shall be one pouch. The inspection level shall be I and the acceptable quality level (AQL), expressed in terms of defects per hundred units, shall be 0.65 for major defects and 4.0 for minor defects.

TABLE I. Filled and sealed pouch defects 1/

<u>Category</u>		<u>Defect</u>
<u>Major</u>	<u>Minor</u>	
101		Tear, hole, or open seal
102		Seal width less than 1/16 inch 2/
103		Presence of delamination 3/
104		Unclean pouch 4/
105		Pouch has foreign odor
106		Any impression or design on the heat seal surfaces which conceals or impairs visual detection of seal defects 5/
107		Osmotically dried fruit missing from overwrap pouch
108		Presence of stress cracks or material degradation in the aluminum foil 6/ 7/
	201	Label smudges, is missing, incorrect, or illegible
	202	Tear nick, notch or serrations missing or does not facilitate easy opening
	203	Seal width less than 1/8 inch but greater than 1/16 inch
	204	Presence of delamination 3/

1/ Any evidence of rodent or insect infestation shall be cause for rejection of the lot.

2/ The effective closure seal is defined as any uncontaminated, fusion bonded, continuous path, minimum 1/16 inch wide, from side seal to side seal that produces a hermetically sealed pouch.

3/ Delamination defect classification

Major - Delamination of the outer ply in the pouch seal area that can be propagated to expose aluminum foil at the food product edge of the pouch after manual flexing of the delaminated area. To flex, the delaminated area shall be held between the thumb and forefinger of each hand with both thumbs and forefingers touching each other. The delaminated area shall then be rapidly flexed 10 times by rotating both hands in alternating clockwise-counterclockwise directions.

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Care shall be exercised when flexing delaminated areas near the tear notches to avoid tearing the pouch material. After flexing, the separated outer ply shall be grasped between thumb and forefinger and gently lifted toward the food product edge of the seal or if the separated area is too small to be held between thumb and forefinger, a number two stylus shall be inserted into the delaminated area and a gentle lifting force applied against the outer ply. If separation of the outer ply can be made to extend to the product edge of the seal with no discernible resistance to the gentle lifting, the delamination shall be classified as a major defect. Additionally, spot delamination of the outer ply in the body of the pouch that is able to be propagated beyond its initial borders is also a major defect. To determine if the laminated area is a defect, use the following procedure: Mark the outside edges of the delaminated area using a bold permanent marking pen. Open the pouch and remove the contents. Cut the pouch transversely not closer than 1/4 inch ( $\pm$  1/16 inch) from the delaminated area. The pouch shall be flexed in the area in question using the procedure described above. Any propagation of the delaminated area, as evidenced by the delaminated area exceeding the limits of the outlined borders, shall be classified as a major defect.

Minor - Minor delamination of the outer ply in the pouch seal area is acceptable and shall not be classified as a minor defect unless it extends to within 1/16 inch of the food product edge of the seal. All of the minor outer ply delamination in the pouch seal area of isolated spots of delamination in the body of the pouch that do not propagate when flexed as described above shall be classified as minor defects.

4/ Outer packaging shall be free from foreign matter which is unwholesome, has the potential to cause pouch damage (for example, glass, metal filings) or generally detracts from the clean appearance of the pouch. The following examples shall not be classified as defects for unclean:

a. Foreign matter which presents no health hazard or potential pouch damage and which can be readily removed by gently shaking the package or by gently brushing the pouch with a clean dry cloth.

b. Dried product which affects less than 1/8 of the total surface area of one pouch face (localized and aggregate).

c. Water spots.

5/ If doubt exists as to whether or not the sealing equipment leaves an impression or design on the closure seal surface that could conceal or impair visual detection of seal defects, samples shall be furnished to the contracting officer for a determination as to acceptability.

6/ Applicable to form-fill-seal pouches only.

7/ To examine for stress cracks, the inside surface of the tray-shaped bodies shall be placed over a light source and the outside surface observed for the passage of light. Observation of light through the pouch material in the form of a curved or straight lines greater than 2 mm in length shall be evidence of

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the presence of stress cracks. Observation of light through the pouch material in the form of a curved or straight line 2 mm in length or smaller or of a single pinpoint shall be considered a pinhole. Observation of ten or more pinholes per pouch shall be evidence of material degradation.

(3) Seal testing. The pouch seals shall be tested for seal strength as require in a, b, or c, as applicable.

(a) Unfilled preformed pouch seal testing. The seals of the unfilled preformed pouch shall be tested for seal strength in accordance with ASTM F 88 - Seal Strength of Flexible Barrier Materials. The lot size shall be expressed in pouches. The sample size shall be the number of pouches indicated by inspection level S-1. Three adjacent specimens shall be cut from each of the three sealed sides of each pouch in the sample. The average seal strength of any side shall be calculated by averaging the three specimens cut from that side. Any average seal strength of less than 6 pounds per inch of width or any test specimen with a seal strength of less than 5 pounds per inch of width shall be cause rejection of the lot.

b. Pouch closure seal testing. The closure seals of the pouches shall be tested for seal strength in accordance with ASTM F 88. The lot size shall be expressed in pouches. The sample size shall be the number of pouches indicated by inspection level S-1. For the closure seal on preformed bags, three adjacent specimens shall be cut from the closure seal of each pouch in the sample. For the form-fill-seal pouches, three adjacent specimens shall be cut from each side and each end of each pouch in the sample. The average seal strength of any side, end or closure shall be calculated by averaging the three specimens cut from that side, end or closure. Any average seal strength of less than 6 pounds per inch of width or any test specimen with a seal strength of less than 5 pounds per inch of width shall be cause for rejection of the lot.

c. Internal pressure test. The internal pressure resistance shall be determined by pressurizing the pouches while they are restrained between two rigid plates spaced  $1/2 \pm 1/16$  inch apart. The sample size shall be the number of pouches indicated by inspection level S-1. If a three seal tester (one that pressurizes the pouch through an open end) is used, the closure seal shall be cut off for testing the side and bottom seals of the pouch. For testing the closure seal, the bottom seal shall be cut off. The pouches shall be emptied prior to testing. If a four-seal tester (designed to pressurize filled pouches by use of a hypodermic needle through the pouch wall) is used, all four seals can be tested simultaneously. The distance between rigid restraining plates on the four-seal tester shall be equal to the thickness of the product  $+1/16$  inch. Pressure shall applied at the approximate uniform rate of 1 pound per square inch gage (psig) per second until 14 psig pressure is reached. The 14 psig pressure shall be held constant for 30 seconds and then released. The pouches shall then be examined for separation or yield of the heat seals. Any rupture of the pouch or evidence of seal separation greater than  $1/16$  inch in the pouch manufacturer's seal shall be considered a

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test failure. Any seal separation that reduces the effective closure seal with to less than 1/16 inch (see table I, footnote 2/) shall be considered a test failure. Any test failure shall be cause for rejection of the lot.  
test failure. Any test failure shall be cause for rejection of the lot.

B. Packing.

(1) Shipping container examination. The filled and sealed shipping containers shall be examined for the defects listed below. The lot size shall be expressed in shipping containers. The sample unit shall be one shipping container fully packed. The inspection level shall be S-3 and the AQL, expressed in terms of defects per hundred units, shall be 4.0 for major defects and 10.0 for total defects.

Major: National stock number, item description, contract number,  
name and address of producer, or date of pack missing,  
incorrect or illegible  
Container nortroperly closed  
Components missing, damaged, or not as specific

Minor: Other require markings missing, incorrect, or illegible  
More than 40 pounds of product

E-6 QUALITY ASSURANCE PROVISIONS (PRODUCT)

A. Classificaion of inspections. The inspection requirements specific herein are classified as follows:

(1) Production standard. The first article or product demonstration model shall be inspected in accordance with the provisions of this Quality Assurance Provisions and Packaging Requirements and evaluate for overall appearance and palatability. Any failure to conform to the performance requirements or any appearance or palatability failure shall be cause for rejection.

(2) Conformance inspection. Conformance inspection shall include the product examination and the methods of inspection cited in this section.

B. Product examination. The finished product shall be examined for compliance with the performance requirements specified in Section C of this Quality Assurance and Provisions and Packaging Requirements utilizing the single sampling plans indicated in ANSI/ASQC Z1.4 - 1993. The lot size shall be expressed in pouches. The sample unit shall be the contents of one pouch. The inspection level shall be S-2 and the AQL, expressed in terms of defects per hundred units, shall be 1.5 for major defects and 6.5 for minor defects. Defect and defect classifications are listed in table II.

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TABLE II. Product defects      1/      2/

<u>Category</u>		<u>Defect</u>
<u>Major</u>	<u>Minor</u>	
<u>Appearance and color</u>		
101		Type I cherries not whole-style
102		Type III, Flavor 3 apples not small cubes
	201	Fruit pieces are clumped together
	202	Color of cherries not bright red to dark red
	203	Color of mango flavored apples not light tan to medium tan
<u>Odor and flavor</u>		
103		Odor or flavor not of sweetened, red cherries
104		Odor or flavor not of sweetened, mango flavored apples
<u>Texture</u>		
105		Fruit pieces are not soft or not chewy

1/ The presence of foreign material, such as, but not limited to dirt, insect parts, hair, wood, glass, or metal, or foreign odors and flavors, such as, but not limited to, stale, rancid, musty or moldy shall be cause for rejection of the lot.

2/ Finished product not equal to or better than the approved first article, when applicable, or other approved model in palatability and overall appearance shall be cause for rejection of the lot.

C. Methods of inspection.

(1) Net weight. The net weight shall be verified in accordance with the label on the commercial package. Product not conforming to the net weight requirement ins Section C of this supplements shall be cause for rejection of the lot.

(2) Nutrient content. The sample to be analyzed shall be a composite of the product from eight filled and sealed pouches which have been selected at random from the lot. The composite sample shall be prepared and analyzed for magnesium, sinc and folic acid content in accordance with the following methods of the Official Methods of Analysis of AOAC International:

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<u>Test</u>	<u>Method</u> <u>Number</u>
Magnesium	984.27, 985.35
Zinc	984.27, 985.35
Folic Acid	944,12
Calories	1/

Test results shall be reported to the nearest milligram for magnesium and zinc and to the nearest microgram for folic acid. Any result not conforming to the requirements specified in C-2, D. of this supplement shall be cause for rejection of the lot.

1/ The calories content shall be verified by the NLEA "Nutrition Facts" label. Product not conforming to the calorie content as specified in Section C of this supplement shall be cause for rejection of the lot.

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SECTION J REFERENCE DOCUMENTS

DPSC FORM

DPSC FORM 3556 Marking Instructions for Shipping Cases, Sacks and  
Palletized/Containerized Loads of Perishable and Semiperishable  
Subsistence, May 96

FEDERAL SPECIFICATION

L-P-378 - Plastic Sheet and Strip, Thin Gauge, Polyolefin

FEDERAL STANDARD

FED-STD-595 - Colors Used in Government Procurements

NON-GOVERNMENTAL STANDARDS

AMERICAN SOCIETY FOR QUALITY CONTROL (ASQC)

ANSI/ASQCZ1.4-1993 - Sampling Procedures and Tables for Inspection by  
Attributes

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

- B 479 - Specification for Annealed Aluminum Foil for Flexible Barrier  
Application
- D 1238 - Flow Rates of Thermoplastics by Extrusion Plastometer
- D 1505 - Density of Plastics by Density Gradient Technique
- D 1974 - Standard Practice for Methods of Closing, Sealing, and  
Reinforcing Fiberboard Shipping Containers
- D 5118 - Standard Practice for Fabrication of Fiberboard Shipping  
Boxes
- F 88 - Seal Strength of Flexible Barrier Materials

AOAC INTERNATIONAL

Official Methods of Analysis of The AOAC International